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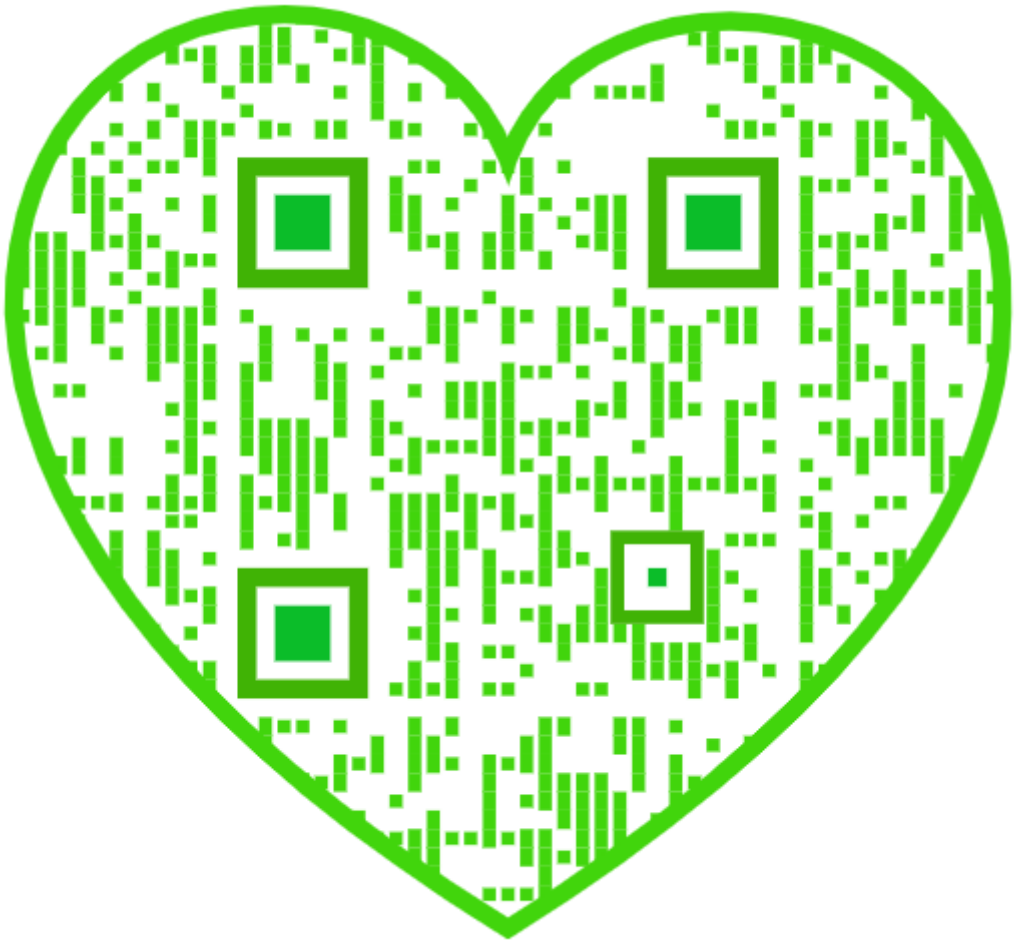

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ANÆSTHESIA IN DENTAL SURGERY

BY

THOMAS D. LUKE, M.D., F.R.C.S. Ed.

SURGEON LIEUT.-COMMANDER, R.N. HOSPITAL, PEEBLES
FORMERLY LECTURER ON ANÆSTHETICS, EDINBURGH UNIVERSITY
ANÆSTHETIST TO THE DENTAL HOSPITAL, THE DEACONESS HOSPITAL
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INSTRUCTOR IN ANÆSTHETICS, ROYAL INFIRMARY, EDINBURGH
AND LECTURER IN ANÆSTHETICS, EDINBURGH UNIVERSITY

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PREFACE TO FOURTH EDITION

WHEN the publishers early in spring last year called for a further edition of this work one of the writers was away in the Eastern field of war, and, after returning for a brief spell, was again called away, but this time to the Western front. The bulk of the preparation has therefore fallen on "the senior partner." Since the return of his collaborator time has been available, however, to incorporate under "sequences" some of the experience in nitrous oxide and oxygen gained and extended in war hospital work.

The main structure of the volume has largely remained as before, but a chapter on ether and chloroform added, largely doing away with the necessity of reference to other manuals.

It is hoped that the value of the work has thereby been enhanced.

Fifteen years ago when the idea of the book, the first of its kind, was conceived, it was refused by more than one publisher on the ground that there was "no field." The fact that we are still running and several kindred volumes have since

appeared again goes to prove that even publishers may make mistakes !

Our thanks are again due to Major Guy for material help in matters in which he has such wide experience and takes such deep interest.

We are also indebted to various manufacturers for the loan of blocks for illustrations, which have been purposely restricted in number, only the principal types of apparatus being figured. For elaborations the reader is referred to the excellent catalogues published by the various manufacturers.

T. D. L.
J. S. R.

April 16, 1919.

PREFACE TO SECOND EDITION

THE progress made in anæsthetic methods during the past two years has necessitated considerable alteration in the text of the previous edition of this little work. Our knowledge of the advantages and the drawbacks of ethyl chloride has been greatly increased during that period, and the section on this anæsthetic has been rewritten in its entirety. The growing popularity of various forms of local anæsthetics has led the author to introduce a great deal of new matter on this most interesting subject. A special chapter has been devoted to the much-debated question—How far is the L.D.S. diplomate entitled to administer the various anæsthetics? The author has considered it best to discuss chloroform in the appendix, for although the use of this drug in dental surgery still obtains, unfortunately, in certain districts, it cannot be considered as having a place in *modern* operative dentistry. Opportunity has been taken to make various little alterations and improvements suggested by kind reviewers and others.

The author desires to express his great indebtedness to Dr. Sauvez, of L'École Dentaire, Paris, for kind permission to allow him to translate portions of Dr. Sauvez' monograph, 'L'Anesthésie locale pour l'extraction des dents,' and incorporate them in the section on Local Anæsthesia. Dr. Sauvez' almost unique experience of upwards of 20,000 cases of extraction under local anæsthetics entitles this section to consideration which the author would be unable to claim for it were it merely based on his own experience of analgesics.

The author desires to acknowledge the help which he has derived in writing the chapter on the choice of the anæsthetic from a most admirable paper on the subject by Mr. William Guy, the text of which has been freely quoted. He is also very much indebted to Mr. W. J. Stuart, M.A., F.R.C.S., for the great care with which he has so kindly gone over the proof-sheets.

Thanks are also due to Messrs. Barth and Co., Claudius Ash and Co., Elliot and Co., and other instrument-manufacturers, for kindly lending electros for purposes of illustration.

T. D. L.

EDINBURGH,
December, 1905.

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CHAPTER I

THE HISTORY OF ANÆSTHESIA

Pioneers of Anæsthetics.

Nitrous Oxide.

Joseph Priestley (England) - - - 1776
Humphry Davy ,, - - - 1800
Horace Wells,* Collyer, Colton, Riggs,* Evans* (U.S.A.), Bert (France) - - - 1844

Ethyl Chloride.

Heyfelder - - - - - - 1848
B. W. Richardson - - - - 1867
Carlson - - - - - - 1896
McCardie, Luke - - - - - 1900

Sulphuric Ether.

M. Faraday - - - - - 1818
W. T. G. Morton* (on himself and on Eben. H. Frost, at Boston, U.S.A.) - - - 1846

'Before whom, in all time, surgery was agony.
Since whom Science has control of pain.'

J. C. Warren (on Gilbert Abbot, 20, painter, single), Long, Jackson, Hayward, Bigelow, Boot,* Robinson,* Liston, Buchanan, Longet, John Snow, Simpson, Bernard, Clover - 1846

Chloroform.

James Young Simpson - - - - 1847
Guthrie, Soubeiran, Liebig - - - 1813
Dumas - - - - - - 1834
Associated with Waldie, Flourens, G. Keith, M. Duncan, Snow, Nunneley, James Arnott.

The extraction of teeth has from the earliest times been looked upon as a most painful and trying

* Dentists.

procedure. It has become proverbial, for do we not say, when speaking of a loss of a very painful nature befalling a person, 'That is an eye-tooth'? During the Dark Ages, in the dungeons of feudal Barons, offending serfs and persons of even higher class had their ears and tongues and *teeth* removed as a punishment and torture; and we are, we believe, not without record of similar proceedings in the chambers of the Inquisition.

There is thus ample historical evidence, did we require it, to prove that the forcible evulsion of our organs of mastication is accompanied by such a degree of pain as to put it in the category of torture.

Accordingly, when civilization dawned upon us, and our digestive organs became simultaneously impaired, painful affections of the teeth arose, calling for their removal on purely humanitarian grounds, at first by any good Samaritan, but later by a special class of men, who became known as 'dentists,' which has evolved itself into the dental profession of the present day.

Called upon to constantly carry out this exceedingly painful operation on their fellow-men, women, and children, it is not to be wondered at that some of the profession, perhaps endowed with a greater love of their fellows than others and a spirit of research, set themselves to find

some substance capable of allaying or completely abolishing the suffering which they were unavoidably causing. Such men were Horace Wells, Morton, Riggs, and Evans, the pioneers of anæsthesia in dental surgery.

The Discovery and Demonstration of the Anæsthetic Properties of Nitrous Oxide.

A romance could be written about nitrous oxide, which Joseph Priestley discovered as a chemical compound in 1776. He was given to inhaling all sorts of vapours; he was the first to inhale oxygen, and, of course, he inhaled nitrous oxide.

It is, however, to Humphry Davy who began life as an apprentice to Mr. Borlase, a medical man in Bodmin, Cornwall, and who afterwards went to be an assistant in his pneumatic establishment at Bristol to Dr. Beddoes—that we owe the remarkable researches on this substance, carried out for a period of two years, and published in 1800, when Davy was only twenty-two. With nitrous oxide Davy experimented on plants, animals, and men, among the last being the poets Coleridge and Southey.

It was in 1799 he first inhaled gas himself, 'when cutting one of the unlucky *dentes sapientiæ*.' After three or four doses of nitrous oxide the pain, which was very severe, diminished. In 1810 he

published an account of his observations on nitrous oxide. Nothing, however, which could be designated conclusive in its relation to surgery resulted from Davy's work. He merely remarked that 'nitrous oxide ay probably be used with advantage during surgical operations.' The surgical profession of his day, however, were sceptical, and did not think the thing worthy of their attention.

The modern practice of anæsthesia, though it may have been benefited indirectly by these experiments and observations, was not the immediate outcome of them; it originated to a large extent independently, and nearly half a century passed by before anyone attempted to utilize nitrous oxide for anæsthetic purposes.

The Introduction of Nitrous Oxide into General Use.

One winter's night in December, 1844, a number of the inhabitants of Hartford, Connecticut, U.S.A., were assembled to hear a lecture on the 'Chemistry of Nitrous Oxide and Other Gases' by Dr. Colton, a well-known popular lecturer. In addition to describing their constitution and properties, he tried the effect of the inhalation of the first-named gas on some of the audience.

Among the people present were Horace Wells

and his friend John Riggs, both dentists of the city. They were astonished to see that one of the persons who inhaled the gas apparently felt no pain from a severe injury he sustained to one of his legs while capering about the hall when partially recovered from its influence.

Wells was so impressed with this fact that on the following day he begged Dr. Colton to allow him to inhale some of the gas, and while under its influence he had one of his molars extracted quite painlessly. On regaining consciousness and realizing what had been done, he exclaimed, 'A new era in tooth-pulling!' Wells was so favourably impressed with his own experience that he immediately proceeded to give the gas to his own patients, and did so to more than a dozen with complete success. Elated with his good fortune, he readily obtained leave to make a public demonstration of the method of employing gas at Massachusetts General Hospital. Unfortunately, the bag and face-piece were removed too soon, and in the extraction of the tooth the patient uttered a piercing cry. The audience, already inclined to be sceptical, hissed and hooted loudly, and Wells was laughed at as an ignorant pretender. Being a modest and rather sensitive man, he felt the insult deeply, and went home mortified and disgusted. Both he and Riggs continued to use

the gas in their private practice, but never again attempted a public demonstration. His claims to being the discoverer of modern anæsthesia were ignored, and, indeed, we are only now beginning to do his memory justice.

He never attempted to make a secret of his discovery, nor to use it for selfish ends.

His failure to convince the public of the genuine nature of his discovery, and to bring the gas into general use, so preyed on his mind that in a few years he fell ill and retired from his profession. He gradually became more and more unsettled in his mind, and finally made an end to himself in a pathetically appropriate manner by inhaling ether to excess in January, 1848.

A handsome monument, with a statue of Wells, has been erected at Hartford, and on it is the following legend:

HORACE WELLS,
WHO DISCOVERED ANÆSTHESIA,
Dec. 10th, 1844.'

With Wells, for the time being, the use of nitrous oxide as an anæsthetic died out, and the discovery was again in danger of being lost.

Dr. Colton for some years tried his utmost to bring it into general use, but his efforts were quite futile until 1863, when he succeeded in getting a few dentists to try it.

After this it was largely employed by the dental profession in U.S.A., and in 1867 Colton came to Paris to read a paper on the gas, recording upwards of 20,000 administrations without a single mishap.

The Paris faculty were not enthusiastic, but in the spring of 1868 Dr. Evans, a very fashionable American dentist resident in Paris, came to London, and most successfully demonstrated the usefulness of nitrous oxide before the staff of the Dental Hospital, so that since then it has come into universal use.

The Discovery and Demonstration of the Anæsthetic Properties of Ether.

In 1818 Michael Faraday found that the effects following the inhalation of sulphuric ether were like those produced by nitrous oxide, and Sir Thomas Watson recorded how his patient, Lady Martin, felt 'as if going to heaven in a most heavenly way' when inhaling it for some chest affection.

A year later William T. Morton was born in Charlton, Massachusetts. In 1843 he qualified as a dentist and M.D., and entered into a successful practice in Baltimore. Fired with the same ambition as his partner, Horace Wells, he made attempts to extract teeth painlessly with the assistance of drugs and even hypnotism. In

December, 1844, after Wells' failure with N_2O, he wisely abandoned this agent, and investigated another which promised better results. He first tried chloric ether, which, as we shall find later, was the substance Simpson started with, but failing to get good results, and at the suggestion of Jackson, a very skilful chemist in Boston, he proceeded to try the effect of sulphuric ether. His first experiments were made on animals, and were so encouraging that he believed he had at last found the desired agent, provided the effect on human beings corresponded with that on dumb creatures. He boldly made experiments on himself, and on September 30, 1846, inhaled ether from a handkerchief while shut up in a room and seated in his own operating chair. He speedily lost consciousness, and in seven or eight minutes awoke in the possession of one of the greatest discoveries that had ever been revealed to suffering humanity. We can picture the man gradually awakening in his chair, first to the consciousness of his surroundings, and then to the consciousness of his great achievement.

First Use of Ether in General Surgery.

On October 16, 1846, the first surgical operation was performed under ether. The scene of this memorable event was the Massachusetts General

Hospital, Boston, U.S.A. Early in October of that year Morton called on the senior surgeon of the hospital, Dr. Collins Warren, and asked that a means of preventing pain in operation which he professed to have discovered might be tried in a surgical case. Warren, having made inquiries as to the method proposed and its freedom from danger, invited Morton to put it to the test on Friday, October 16. On the eventful morning a large number of doctors assembled in the theatre. Morton was somewhat late, having been detained by some difficulty in getting a suitable inhaler. The spectators, sceptical enough to begin with, not unnaturally became still more so when it appeared as if the champion of the new invention dared not show his face in the lists. After waiting fifteen minutes, Dr. Warren said with significant emphasis: 'Dr. Morton has not yet arrived; I presume he is otherwise engaged.' The remark was followed by a derisive laugh, and Warren was on the point of commencing the operation when Morton entered the theatre. His reception was the reverse of encouraging, Warren saying to him coldly: 'Well, sir, your patient is ready.' The young dentist proceeded to administer the ether, and in a few minutes the patient was unconscious, whereupon Morton said quietly to Warren: 'Your patient is ready, sir.' The surgeon's knife did not

awaken the patient from the deep sleep into which he had been passed, and the spectators looked on with wonder deepening into stupefaction. When the operation was over, Dr. Warren said in a solemn voice: 'Gentlemen, this is no humbug!'

The news soon spread to Europe, and the first administration of ether to induce anæsthesia in England took place on December 19, 1846, at 24, Gower Street, London, the house of Dr. Booth, to whom the news of Morton's discovery was communicated by Dr. Bigelow, of Boston. On the 22nd of the same month Liston amputated a limb under ether in the University College Hospital, and so intense was the emotion of the great surgeon on this occasion that, when he turned to address the spectators after the operation, he could hardly speak.

Failure of Morton to patent Ether, and his Death.

Morton endeavoured to keep the nature of his discovery secret, and to patent it under the name of 'Letheon.' In this, however, he failed, and the exact nature of the agency was only kept secret for a very short time. The characteristic smell of ether, so familiar to all the medical profession even at that time, soon betrayed its character.

Morton cannot be said to have derived much

benefit from his discovery himself. He certainly received several honours and presents, but his fruitless endeavours to obtain State recognition of a monetary nature, together with prolonged squabbles and controversies concerning his discovery, worried him into a state of ill-health, and very soon into an early grave.

The Invention of a Suitable Inhaler for Ether.

Joseph Thomas Clover was born at Aylsham, Norfolk, in 1825. After being apprenticed to a Norwich surgeon, he entered University College, London, where he distinguished himself as a student. In 1853 he began practice in London, and became an F.R.C.S. His natural inclinations were in the direction of surgical practice, but repeated attacks of ill-health made him confine his attention to anæsthetics. It has been said of him that it was a matter of doubt whether the art of surgery lost or anæsthesia gained the more by this. He was a man full of ingenuity and resource. His inventions were numerous, and he was a pioneer in the modern art of anæsthesia. His name will be perpetuated by his ether inhaler, which since he brought it out in 1877 has always been, *facile princeps*, the best apparatus with which to administer ether.

The Introduction of Chloroform.

While the discoverer of ether was wasting his time and money in dispute concerning priority, and Wells was dying from chagrin and inaction, a bolder and higher type of man than either had taken up the work where they had left it, with the high object of pursuing it until he had for ever established the benefit to humanity which he recognized in it. This man was James Young Simpson. He was born at Bathgate, in West Lothian, in 1811. He entered the University of Edinburgh in 1828, where he had a very distinguished career as a student, and took his M.D. degree in 1832. In 1840 he was appointed to the Chair of Midwifery after a severe struggle. Placed in this position at the age of twenty-nine, Simpson soon showed himself highly qualified for it. His lecture-room was thronged by eager students. His fame quickly spread, and patients came to him from every part of the world. He was one of the first to call attention to the evils of 'hospitalism,' and he suggested that a separate system should be adopted for patients, instead of aggregating them in crowds in disease-tainted wards. When anæsthesia came before the world, Simpson at once gave his mind to the subject. He was the first (January, 1847) to apply ether to

the mitigation of the pains of childbirth. Not being quite satisfied with that agent, for want of proper apparatus for its administration, he set to work to discover some other anæsthetic free from what he considered its drawbacks.

Dangerous Experiments with Chloroform.

He tried a number of different substances on himself, and more than once came near falling a martyr to his zeal for knowledge. At last, acting on a hint from David Waldie, a Liverpool pharmacist, he tried chloroform. He was not aware that early in 1847 a French chemist—Flourens—had drawn attention to its effect on animals, or he would not have put away untried the first specimen sent him, as it appeared to him heavy and non-volatile, and seemed unlikely to be an efficacious anæsthetic by inhalation.

However, late one evening early in November, 1847, on returning home after a heavy day's labour, Simpson and his two friends and assistants, Drs. Matthews Duncan and George Keith (who is still alive), sat down to their somewhat hazardous experiments in Simpson's dining-room in Queen Street, Edinburgh. After inhaling several substances without much effect, it occurred to him to try the neglected specimen of chloroform. All three charged their tumblers with the drug, and

began to inhale it. Very soon an unwonted hilarity seized the party; they became bright-eyed and very loquacious, expressing their high approval of the aroma of the fluid.

Their conversation was of quite unusual intelligence, and quite charmed the friends who were watching their experiments. But suddenly their voices became louder, their expressions exclamatory, then unintelligible. A moment more and all was quiet, and then there was a crash.

On awakening, Simpson's first perception was mental. 'This is better and far stronger than ether,' he remarked. He then noted the fact that he and his two colleagues were prostrate on the floor. Dr. Duncan, with his eyes staring and his jaw dropped, was snoring in an alarming manner, while Dr. Keith, partially awakened, was making vigorous attempts to kick over the supper table! In a few minutes all three completely regained their consciousness and seats, and each expressed his delight with the new agent, which they again repeatedly inhaled.

The following morning Mr. Duncan, of Duncan and Flockhart, was pressed into their service to prepare a large supply of the drug, and Simpson made an immediate trial of it in his midwifery practice, with such success that on November 10, 1847, he read before the Medico-Chirurgical

Society of Edinburgh a paper entitled 'Notice of a New Anæsthetic Agent as a Substitute for Sulphuric Ether.'

Professor Miller sent for Simpson a few days after the discovery of chloroform to ask him to give it to a patient on whom he was about to perform a major operation. Simpson was, as luck would have it, prevented from attending, and Miller began the operation without him. At the first cut of the knife the patient fainted and died.

Had chloroform been administered, one can readily imagine what a blow this untoward event would have been to Simpson and to the cause of anæsthesia.

Subsequently, however, he gave it with great success to patients of Professor Miller and other of his colleagues, while in his own obstetric practice he used it as a matter of routine, and there is no doubt that the kudos he gained among the fair sex from being the first to mitigate the pains of labour added vastly to his already growing reputation.

Chloroform soon came into general use in this country in place of ether, and the word itself became so common in the vernacular that the people began to recognize it as synonymous with and more expressive than an anæsthetic. It may have been this fact that led Simpson in the

'Encyclopædia Britannica' to deal with the subject of anæsthesia under the heading 'Chloroform,' but a less charitable interpretation was placed on his conduct by our American cousins. There can be no doubt, however, that to Simpson belongs not only the honour of introducing chloroform, but the merit of popularizing anæsthesia both with the profession and with the public. His energetic advocacy bore down all the opposition that ignorance, superstition, prejudice, and scientific jealousy mustered against it. His name will long live, not only as the introducer of chloroform, but as the reformer of obstetric medicine, which he found the despised art and left an honoured science.

The idea prevailed for some time that $CHCl_3$ was absolutely safe, but the death of a young woman named Hannah Greener, on January 28, 1848, at Alloa, while being operated on for an ovarian tumour, Simpson himself acting as chloroformist, soon showed that it was an erroneous one. From time to time similar casualties occurred, and it soon became obvious that, whatever advantages the new system of inducing insensibility might possess, the administration of chloroform was by no means without grave risks to life.

As death after death was reported, every conceivable and inconceivable theory was advanced

to explain them. The most deplorable ignorance, however, prevailed, and several years went by before any satisfactory light was thrown on their causation.

The Introduction of Ethyl Chloride as a General Anæsthetic.

The career of ethyl chloride as a general anæsthetic has been almost as chequered as that of nitrous oxide, for it has taken upwards of half a century to establish its position and gain the confidence of the medical and dental professions.

In 1848 Heyfelder first employed the drug to induce general anæsthesia in the human subject. For a number of years after that, however, ethyl chloride remained entirely in desuetude, although several observers commented favourably on its value. In 1867 B. W. Richardson experimented with it, and found it "a good and safe anæsthetic"; but his remarks do not seem to have attracted the notice of the profession, and we do not find any record of the practical use of this drug for a period of nearly thirty years after this. In 1896 Carlson, the Director of the Dental Institute in Gothenberg, showed that in certain cases where local analgesia of the gums was produced by means of the ethyl chloride spray, the patient became quite uncon-

scious. He rightly concluded that this was due to inhalation of the ethyl chloride vapour.

Thiesing Billeter and other Continental surgeons and dentists then employed it as a general anæsthetic with good results, and during the next few years several thousand cases were recorded, and favourably commented on in the foreign medical and dental journals.

In 1902 McCardie of Birmingham began to use the drug, and in March of that year published an article in the *Lancet* drawing attention to its value as a general anæsthetic agent. Subsequently he published several other papers with series of cases, and it was primarily due to his advocacy that ethyl chloride was taken up in this country.

About the same time demonstrations of an anæsthetic nostrum known as 'somnoform' (consisting for the most part of ethyl chloride) were given at various dental hospitals throughout the country, and there is no doubt that these attracted to a great extent the attention of the dental profession to the matter. The market was speedily flooded with all kinds of proprietary preparations under fanciful names, but actually consisting of ethyl chloride and nothing else, while in a short time inhalers innumerable, suitable and unsuitable, were introduced for ad-

ministering the drug. Ethyl chloride was, for some four years (1901–1905) administered broadcast by all and sundry, and this would constitute a most trying test for any anæsthetic whatever; yet comparatively few deaths have been actually recorded—about a score—though there can be little doubt that some more have occurred which have not been brought to light. Be that as it may, one can have no doubt that in ethyl chloride we have a most valuable anæsthetic agent for dental surgery.

Anæsthetic Apparatus.

Improvements and Modifications of Inhalers.—In the early days inhalers and apparatus used in connection with anæsthetics were certainly either conspicuous by their absence or elementary in the extreme. Now the pendulum has swung the other way, and the variety is bewildering in its immensity. A glance over any instrument-maker's catalogue in the last ten years in this section really gives food for astonishment, as there appears to be hardly an anæsthetist who has not 'modified' a previously existing inhaler, if he has not actually brought out quite a new type under his own name. Turn we to American books and catalogues, and the position is much the same. We are as grieved to see that distinctly septic types

remain, such as the Hyderabad cone of leather and felt, as we are to observe later types involving an electric motor to drive them and possibly a taxi-cab to take them around from one case to another !

We trust we may hurt no one's feelings; we admit that one of us at least has in past years yielded to the temptation to allow his name to be attached to a type of inhaler from the sale of which the maker got the profit, leaving such honour and glory as may have been deserved to the designer. But is it not time to call a halt ? Frankly our opinion is that since Clover invented his closed inhaler no worker in this field has in basic principle added anything very noteworthy to our armamentarium, if we except the late Sir Frederick Hewitt—a man whose modesty and charm of character was only equalled by his extreme originality and enthusiasm for the field of work he adopted.

The wide bore is certainly an advance, if not indispensable—a really skilled anæsthetist will do almost as good work with a well-made Clover.

Hewitt's work with gas and oxygen is noteworthy, and his apparatus adapted to the nasal method has been perfected by Bellamy Gardner.

Every anæsthetist worth his salt will from time to time like to make some experiments, and a new apparatus made by himself or a friendly rival has

its attractions. He will end, probably, in discarding most of them, fill a small attic with perishing rubber and dull nickel plate, and recall with regret the many guineas which he has laid out in vain. *Poeta nascitur, non fit*—and the anæsthetist is the same, with this primary postulate: it cannot be too strongly emphasized how very secondary a part 'apparatus' play in all anæsthesia.

It is on the eye judgment and skill of the administrator, developed by years of training and experience, that the safety of the patient and comfort of the operator depend.

The older anæsthetist develops a wholesome conservatism without necessarily getting out of date. His methods and apparatus are few and simple usually; he relies rather on the *tactus eruditus*, and the valves, stop-cocks, and thermophores, are mere details, sometimes easily dispensed with.

It must be pointed out further that the time has now come in everyone's interest for standardization of apparatus on certain broad lines, just as nuts and screws are standardized by engineers. Medical men and dental surgeons have everything to gain by this, and 'the Trade' are not against it. Recently, in conversation with the manager of a large dental emporium, the subject was raised by

one of the authors, and received strong support and approval.

Such people are in business for profit, naturally, and if they are constantly making or stocking new apparatus the sale of which is uncertain, they have to try and make the price of one cover the possible loss on several never sold.

CHAPTER II

THE CHOICE OF THE ANÆSTHETIC FOR DENTAL OPERATIONS

THERE are four factors to be considered in making the choice, viz.—(1) The patient, (2) the operation, (3) the operator, and (4) the person who administers the anæsthetic.

1. THE PATIENT.

The age of the patient is the primary consideration, and with children and old people we have dealt fully elsewhere. For young healthy adults and middle-aged people nitrous oxide gas is best adapted if a brief anæsthesia only be required.

Sex has little influence on our choice, but the position in life of the patient has a considerable influence on behaviour under an anæsthetic. Thus, if we exclude hysterical women and alcoholics of both sexes, members of the upper and middle classes take anæsthetics quietly, generally speaking, and regain consciousness without any undue display of the emotions.

'The masses, whose emotions and instincts are undisciplined, and who have never practised any degree of self-control, or experienced any control, parental, sacerdotal, or magisterial—who are, in short, uneducated, though they may have passed through a course of elementary instruction—will often resist, scream, swear, kick, and otherwise misconduct themselves during the administration and after the recovery. Alcoholics, loose women, and football-players, when gas and ether or gas and ethyl chloride are being administered to them, should be brought more fully under the gas before the ethyl chloride or ether is introduced than would be necessary in the case of less excitable patients. The state of the patient's health is important, but does not require very long consideration here, because if the patient is fit for the operation he is fit for the anæsthetic. No doubt there are many conditions in which the administration of the anæsthetic is attended with grave risks, and must give rise to anxiety. This may be truthfully said, for instance, of acute intestinal obstruction, depressed fracture of the skull, the terminal stages of exhausting diseases, or of dyspnœa from the narrowing or obstruction of respiratory passages by the presence or pressure of growths. But patients exhibiting these conditions are seldom sent to

have their teeth extracted under anæsthetics. There are many conditions which call for care and skill on the part of the anæsthetist. Advanced atheroma, chronic bronchitis, Bright's disease, advanced phthisis pulmonalis, valvular disease of the heart, especially with failing compensation, aortic aneurism, pernicious anæmia, and diseases of the central nervous system are a few of these' (Guy).

2. The Operation.

If one or two teeth only require to be extracted, nitrous oxide is the best anæsthetic, unless there be some contra-indication, from being most usually available.

If there be five or six teeth of uncertain difficulty to extract, the choice will lie between continuous gas administration by the nasal method and a mixture of nitrous oxide oxygen and ethyl chloride.

If there be a greater number of teeth or a very difficult tooth, such as an impacted wisdom, then gas and ether or ethyl chloride and ether sequence should be used.

3. The Operator.

Where the operator unfortunately requires to fulfil the double function of operator and anæs-

thetist, he has to calculate the time he will need, and gauge his own dexterity as an extractor. On the other hand, if, as should always be the case, a separate individual act as anæsthetist, his proper course is to ask the dental surgeon who is to operate what time he thinks it likely he will require, and then choose his anæsthetic accordingly. The anæsthetics at his disposal are the following: Nitrous oxide gas, ethyl chloride, gas and ethyl chloride sequence, nitrous oxide (nasal method), gas and ether sequence, ethyl chloride and ether sequence, ethyl chloride and C.E. sequence, C.E. and ether sequence, and local anæsthesia. The available anæsthesia with these will be somewhat as follows:

Nitrous oxide	.. 35 seconds.
,, ,, and eth. chlor.	.. 90 to 120 seconds.
,, ,, and oxygen	.. 90 to 120 seconds.
,, ,, (nasal method)	.. 1 to 5 minutes.
,, ,, and ether	.. 1 to 10 minutes.
Ethyl chloride	.. 1 to 2 minutes.
Ethyl chloride and ether	.. 1 to 10 minutes.
Ethyl chloride and C.E.	.. 2 to 5 minutes.
C.E. and ether sequence	.. 3 to 10 minutes or *ad lib.*
Local anæsthesia ..	.. As required.

4. The Anæsthetist.

The person responsible for the anæsthetic will be influenced by various considerations. In a dentist's room or at a hospital, gas or gas and ether

will receive his first consideration, but if the operation is to be done at the patient's house, and possibly at a distance, the greater portability of ethyl chloride will influence him in its favour. We are now supposing that the administrator is familiar with all the anæsthetics which we have enumerated, but, unfortunately, this is frequently very far from the case; indeed, when the individual in question is a country practitioner, his experience is restricted in most cases to two anæsthetics, generally chloroform and ether; too often, north of the Tweed, to chloroform alone. Guy says: 'In the latter case, I think it is the duty of the dentist to state very plainly to the doctor his preference for some other anæsthetic than chloroform, to insist on the operation taking place elsewhere than at his house (if chloroform be used), and to make it clear that he disclaims and is absolved from any responsibility for any untoward result.' With this expression of opinion the authors are entirely in accord. Elsewhere their views are stated on this question *in extenso*.

Anæsthetics in Special Cases.

Children.—Children of tender years are by no means good subjects for nitrous oxide. It is often well-nigh impossible to maintain a satisfactory anæsthesia for anything but the shortest

dental operation in a child under seven years of age by means of this anæsthetic, the difficulty increasing the younger the child is. In the first place, we have all a dread of the unknown, and in children this is especially the case; the apparatus looks formidable, and may terrify the little patient.

Again, it is difficult for the dentist to operate so rapidly as on an adult, for the mouth is small and the forceps large, while there may be cyanosis and spasm, jactitation, and not uncommonly screaming on the patient's part. In this connection, it is often very difficult to persuade the friends who may be present that the child has felt nothing, for the crying and jerking of the body and limbs seem to the uninitiated to be the outward and visible manifestation of a painful sensation.

The degree of success which is attained with this class of patient will largely depend on the tact and patience of the person conducting the administration. His patience and powers of persuasion will in some cases be strained to the utmost, often not more by the child, however, than by a foolish and doting parent. It is useless to lose one's temper in any case, and perseverance in this, as in most things, will win the day.

If the insertion of the mouth-prop be much ob-

jected to, the administration may be commenced and a prop slipped in when the sensibilities have become somewhat duller, or a mouth-opener be used when complete anæsthesia has been established.

Breaths of air should be given, one to every five respirations when nitrous oxide is administered, so that cyanosis may be lessened and anæsthesia prolonged. For the extraction of the four six-year-old molars Paterson's apparatus for the nasal administration of gas is most valuable, but unless the administrator is familiar with it, ethyl chloride or gas and ethyl chloride should be used.

Patients who are advanced in Years.—Patients over sixty years of age, if in good health, usually take nitrous oxide well; they pass quickly under its influence, and though cyanosis is rather marked, the anæsthesia is long in duration, and profound compared with young adults. The addition of a little oxygen to the nitrous oxide will in many cases be found advantageous. In dealing with such patients, however, it must be remembered that they are frequently the subjects of senile changes in the way of thickened and brittle arteries, feeble hearts and diminished respiratory power.

Special watchfulness is needed, and the possibility of apoplexy, if nitrous oxide be pushed, is to be borne in mind.

The presence of 'winter cough' or chronic bronchitis should be inquired after, and, if the patient suffers in this way, ether should be avoided or given sparingly. The gas and ethyl chloride sequence, or ethyl chloride alone, is well suited to people of advanced years.

Heart Disease.—Although nitrous oxide is by no means contra-indicated in cardiac disease, all such cases should be treated with additional care, and the anæsthetic be given by an expert anæsthetist or in the presence and with the help of a fully-qualified medical man. To satisfy the patient, at least, it is well that the physician should feel the pulse at the wrist before starting the anæsthetic, and in some cases the preliminary administration of a little brandy or other alcoholic stimulant is of value. The cyanosis often becomes marked at an early period of the inhalation, and the pulse (which should be kept under observation throughout the administration) becomes slower; if any sign of intermittence is noticed, the gas should be immediately withdrawn. Ethyl chloride and ethyl chloride and ether may be given with safety.

Pulmonary Disease.—Patients suffering from any pulmonary affection are not good subjects for any anæsthetic, particularly if there be any tendency to dyspnœa; the emphysematous and bron-

chitic take nitrous oxide badly, often becoming intensely livid, and they may succumb from heart failure, for their blood is inefficiently aerated, and the right side of the heart is already overloaded. Patients suffering from tubercular disease of the lungs also require special consideration and careful treatment. When there are large cavities in the lungs in advanced years, the loss of breathing space impedes the action of the gas, while in all cases early and late hæmoptysis may be brought on by the administration of nitrous oxide and ether.

Further, if chloroform be given, these patients often give trouble during the anæsthesia, and make a bad recovery, suffering from vomiting, and giving evidence of general systemic depression for days.

If, therefore, chloroform be employed for some special reason, it should be administered along with oxygen, for this combination gives a much better type of anæsthesia, and the after-effects are usually very slight.

Unless this course be adopted, the alternative one is, if an extensive extraction be required, to have several sittings, and to remove three or four teeth at a time under gas and oxygen anæsthesia. The necessity for these precautions should be carefully explained to the patient.

Further, the greatest possible care should be taken to sponge thoroughly and maintain oral asepsis while the gums are healing, so as to prevent any secondary infection of the lung of a septic nature, which, if it supervened, would place the patient in a position of great jeopardy.

Nervous Disorders.—Epileptic and choreiform seizures are recorded as having been induced by the inhalation of nitrous oxide and other anæsthetics. The author has seen several such cases when gas was being administered, but they are not of sufficiently frequent occurrence to warrant refusing to administer gas to persons who are subject to epileptiform or choreic attacks.

Cases of insanity and mental aberration following artificial anæsthesia have been recorded. Savage has drawn special attention to this question (*British Medical Journal*, December 3, 1887). We have personally known of two patients suffering from temporary delusional insanity after inhaling nitrous oxide.

Although on theoretical grounds ether is known to tend to cerebral congestion and mental excitement, there seems to be no contra-indication to the use of gas and ether, or ethyl chloride and ether, for a brief anæsthesia such as is required for dental work among persons who are mentally afflicted. Guy, who has a large experience among this class

of patient, is of this opinion, and the authors are in agreement with him.

As regards *hysteria*, women who are not prone to hysterical manifestations not uncommonly give signs of them when recovering from nitrous oxide or ethyl chloride, and, of course, the tendency is more marked in 'hysterical subjects.' A little tact and firmness, however, is all that is necessary in dealing ith such patients. Their noisy lamentations, and sometimes cataleptic condition, may often be very trying to the busy dentist. The windows should be opened wide, a wet towel applied to the forehead, strong smelling-salts used, while sympathizing friends are removed from the room, and they and the patient from the house as soon as may be.

Pregnancy.—Nitrous oxide may be administered with safety to most patients up to within a month of full term, but care must be taken to avoid pushing the gas and inducing marked clonic contractions. If the patient is very nervous and anxious about the matter, or if she is almost at full term, it will be wiser to substitute the gas and ethyl chloride sequence (or ethyl chloride alone) for nitrous oxide, using every possible precaution.

Alcoholism and Drug Habits.—Patients who are given to the injudicious use of alcohol, and to the use of cocaine and morphia, are disposed to be

unusually troublesome during artificial anæsthesia, and it is well to be on one's guard in dealing with them. With alcoholic patients struggling is always to be expected, and may be very violent and troublesome.

Several assistants may be required to restrain the patient, and all glasses, mirrors, jugs, and trays of instruments should be placed in the background in case of accident.

In the case of morphia maniacs, especially if they have recently had an injection, quite a small amount of anæsthetic may suffice, and care is necessary not to push it too far.

Tobacco Habit.—It is well known that persons addicted to the excessive use of tobacco take anæsthetics badly as a rule. The inveterate pipe-smoker has hypertrophied muscles of mastication. The mucous membrane of his nose, mouth, and pharynx is injected and often œdematous; his uvula is often elongated and swollen, resting on the dorsum of the tongue; and his air-way is thus narrowed. His mucous and salivary glands become larger and more active, and hence the increased salivary secretion. The heart may be dilated and sounds soft; the pulse weak and sometimes irregular. Ether often seriously increases the injection and œdema of the respiratory tract, and sets up a series of spasms, with exces-

sive secretion of mucus, etc.; after a good deal of coughing, the patient becomes lightly anæsthetized, yet his face is livid, and he is half choked by the swollen mucous membrane and retained secretion. The pale, anæmic youth, who smokes an excessive quantity of cigarettes, besides posessing the abnormal respiratory tract of the pipe-smoker, shows evidence of thickening and irritation of the bronchial mucous membrane caused by inhalation of the smoke, which in all probability in some cases actually damages the lung-tissue. In the cigarette-smoker, also, the nervous changes are more marked than in the pipe-smoker. The former is highly strung, nervous, and irritable, and is apt to get fainting attacks. The knee-jerks are increased, ankle clonus sometimes present, and fine tremors of the hands very obvious. When nitrous oxide is administered much is needed; the breathing is shallow in character and struggling of common occurrence.

Ether causes great irritation of the already irritated mucous membrane of the trachea, bronchi, and perhaps even of the alveoli, and probably spasm of the bronchial muscular coats. Moist râles may be heard over the back and front of the lungs, like those of acute bronchitis. The induction of ether or ethyl chloride ether anæsthesia is often unpleasant, and even impossible in some cases.

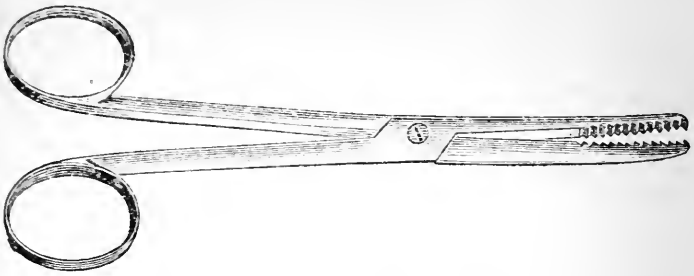

FIG. 1.—BRAINE'S TONGUE FORCEPS.

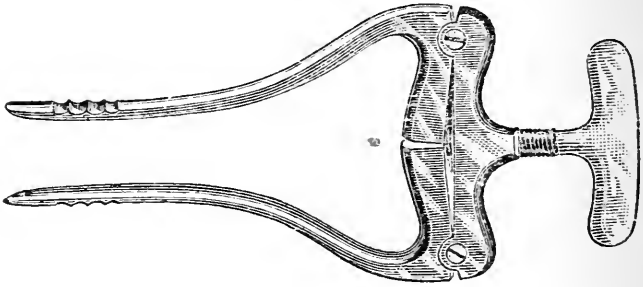

FIG. 2.—HEISTER'S MOUTH-WEDGE.

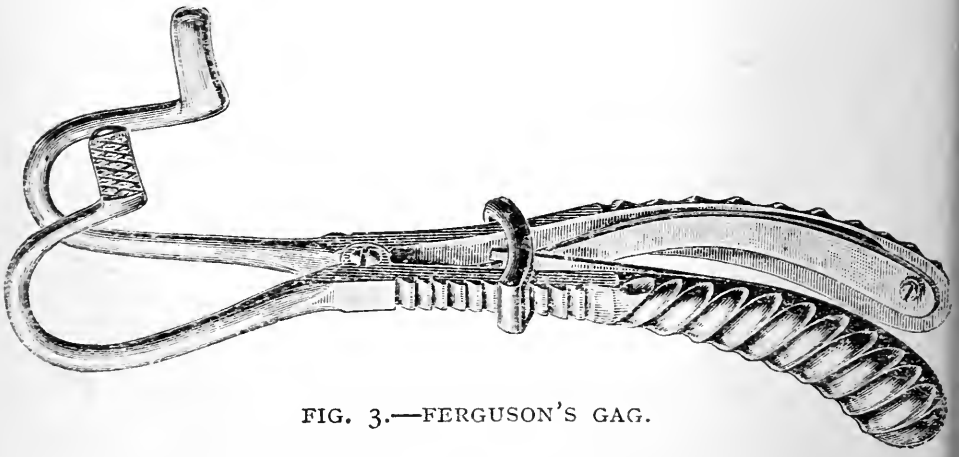

FIG. 3.—FERGUSON'S GAG.

If the insertion of the mouth-prop causes retching, as it often does, this may be overcome in most cases by rinsing the mouth out with a weak

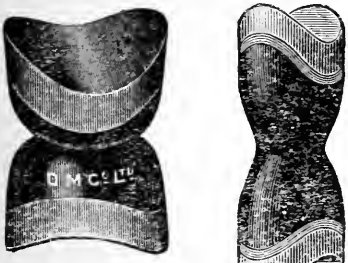

FIG. 4.—VULCANITE PROPS.

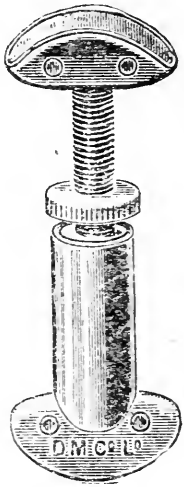

FIG. 5.—TELESCOPIC PROP.

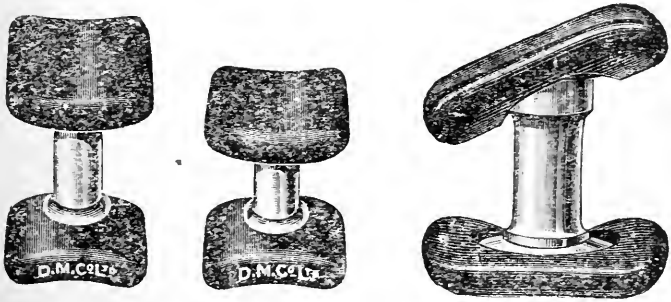

FIG. 6.—HEWITT'S PROPS.

solution of carbolic acid (1 : 100). The combination of oxygen with the gas will greatly lessen the

cyanosis and jactitation. In some cases the use of chloroform and oxygen will be preferable, and even necessary, rather than ether. If ether is employed, however, the previous injection of $\frac{1}{100}$ grain of atropine will be of great use to prevent excessive secretion.

Accessory Apparatus required in Anæsthesia for Dental Operations.

Among these may be specially mentioned the following:

1. Instruments for opening the mouth and keeping it open, such as gags and props.
2. Tongue forceps.
3. Sponge holders.
4. Hypodermic syringe and solution of strychnine (1 : 100).
5. A bib or apron for the patient, to prevent soiling of the clothes.
6. Some sponges of *coarse* texture, or pieces of gauze which can be rolled up to make 'swabs.' The 'aseptic tampons,' tightly rolled in an outside cover of muslin, are practically useless for sponging.

Of gags, there are many kinds. The best one, generally speaking, for dental work is that of Ferguson or Dudley Buxton, with good long

handles which allow of a considerable amount of purchase. Croft's gag finds favour with some people, but the handles do not allow of sufficient purchase, if the patient has a strong jaw or if there is any tendency to masseteric spasm.

The essential points to look to in selecting one are the length of the handles; the tooth-plates of the gag (which should come close together, or lie in the same plane as in Buxton's); a ready means of fixing the gag in any degree of extension; an easily-working joint; and, lastly, good, all-forged blades throughout. A little dexterity in using a gag is readily acquired when once its mechanism is understood, and quickness of application is essential to its successful employment.

As regards *mouth-props*, the most generally useful are the simple ebony or vulcanite ones, with their surfaces padded with indiarubber. Hewitt's pattern and Gardner's, both made of aluminium, are good, but rather too large for use on young children. Some men prefer to use spring gags, such as Buck's; but, generally speaking, these should be avoided, as the spring is very apt to get out of order, and sometimes the two parts of the gag separate at an awkward moment. Further, the adjusting part looks, and *is*, difficult to clean, so that a fastidious patient may object to using it. The following are the chief points

to have regard to in the selection of a mouth-prop:

1. It should be made of hard material, not likely to split or chip, so that it may be scrubbed frequently. The dental surface should be fitted with pads of rubber or some non-absorbent substance.

2. It should be as small as is compatible with strength, or it will be in the operator's way.

3. It should be all one piece, as joints are apt to give way.

4. A strong piece of catgut, silk, or whipcord 10 to 12 inches long should be tied firmly round the stem, and attached to another prop, so as to do away with any chance of the prop going down the patient's pharynx. The string requires frequent renewing, as it soon gets blood-stained and soiled.

A cork properly shaped with a sharp penknife, and tied to a string, makes quite a good emergency gag, but can only be used once or twice. A little care expended on the insertion of the mouth-prop well repays the operator. The prop should always lie quite straight, and be held firmly in the bite. If possible, it should never be placed further forward than the bicuspid teeth, or the masseteric spasm set up during the anæsthesia (if gas or ethyl chloride be used) may be so great as to force out one of the incisors or canines. If it has to be

placed far forward, it should be put between the incisors, and a prop broad enough to overlap two teeth should be employed.

Inhalers recommended for Ordinary Practice.

Every dental surgeon or practitioner who is often called upon to help in dental work will do well to provide himself with Barth's or Hewitt's N_2O apparatus with a three-way stop-cock and 2 or 3 gallon bag.

He will also be wise to acquire an ether chamber (Clover or Hewitt's) to fit the gas apparatus. The gas-bag can be used for ethyl chloride, as Hewitt recommended, with an air-pump and small tube of ethyl chloride attached to the bottom, or he can use an ordinary Clover 1-gallon bag with the hole in the top of the angle-tube, as suggested by one of the authors.

A Schimmelbusch mask is almost an essential in all anæsthetic work, and, while not essential by any means, a Junker may be added for use in such rare cases of dental work as chloroform may be called for.

Anything more than this is a luxury only justified in high-class practice. The specialist will often prefer to give gas by Patterson's method,

or gas and oxygen as suggested by Bellamy Gardner, but that is work rather for the trained anæsthetist than a practitioner.

Certainly it is a moral impossibility for a dentist to use either and operate at the same time.

CHAPTER III

NITROUS OXIDE

NITROUS OXIDE is in all respects, *facile princeps*, the basic anæsthetic for the dental surgeon. Properly used, it is almost entirely free from danger, and is rarely productive of nausea or even temporary depression as after-effects. By means of it about 35 seconds of anæsthesia can be obtained, in the majority of cases in one minute, sufficient time being afforded to allow a dentist of ordinary dexterity to extract from one to five teeth or more. It is essential, however, and only fair to the person acting as anæsthetist, for the operator to have everything in readiness for starting, before the patient begins to inhale, so that every second of the period of anæsthesia may be utilized if necessary.

In these days to extract teeth without the use of ' laughing gas,' except in the case of the most hardy and robust men and in emergencies, is little short of barbarous. It is cruel to the patient, and if the subject is a child, wantonly so. Very

few people can submit to the operation without some resistance, and though this be involuntary, the operator is handicapped by it, and from anxiety to be quick, the liability to break a tooth or portion of the alveolar plate is greatly increased.

Nitrous Oxide (N_2O). Synonyms: Protoxide of Nitrogen, 'Laughing Gas,' or Gas.

Nitrous oxide gas is a colourless body, possessing a rather sweet taste and odour, and a specific gravity of 1·527. It is neutral in reaction, and consists of nitrogen and oxygen in chemical combination, and so differs from atmospheric air, which is simply a mechanical mixture of these gases. Nitrous oxide has been proved to possess well-defined anæsthetic properties, and these are not due to simple displacement of oxygen in the blood, or to a partial asphyxia, but to the fact that the gas enters into a loose combination with the hæmoglobin in the red blood-corpuscles, and is so conveyed to the nerve centres, on which it has a specific action.

It is possible to liquefy nitrous oxide with a pressure of fifty atmospheres at a temperature of 7° C., and the practical and commercial importance of this lies in the fact that the gas can be readily stored in steel or iron bottles, and so conveniently carried about. Liquid nitrous oxide—

specific gravity ·936—is colourless and mobile, and 15 ounces of it will yield 50 gallons of the gas. The pressure in the cylinders containing nitrous oxide often registers 1,000 pounds per square inch. The gas undergoes rapid expansion when heated in any way, and if this be done incautiously without the valve being unscrewed a little so as to allow a slight escape of the gas, the cylinder may burst.

Under very great pressure nitrous oxide will solidify, and becomes white and snowlike in appearance. When gas-bottles are lying horizontally, and the gas is allowed to escape suddenly, it often assumes the solid form, especially on a cold day, and so blocks the outlet. This sometimes gives us the impression that the bottle is empty, but a few minutes later, when the obstructing particles have melted, the gas escapes with a loud explosive report.

Nitrous oxide is prepared by heating granulated ammonium nitrate to 460° F. and collecting the gas evolved over water. The process is comparatively simple, and until recently dentists often prepared their own gas. There are a number of impurities, however, which require removal, and, unless this is effected, they often give an unpleasant and nauseous smell to the gas, and cause irritation of the throat and respiratory passages

of the patient. Accordingly, it is desirable to procure gas only from a reliable maker who carries out the processes necessary for a complete purification of the gas. There is no advantage in using freshly-prepared gas, for when stored in cylinders it keeps perfectly well.

Physiological Action of Nitrous Oxide.

The exact nature of the action of the gas on the human organism was for a long time very imperfectly understood, and from the erroneous conception of its action it came to be regarded as somewhat untrustworthy and even unsafe. It was generally believed that it displaced oxygen from the blood, and when the tissues reached a certain point of cellular asphyxia, they lost their power of receiving and conveying stimuli. The late Sir George Johnson actually contended that the gas merely produced 'a beneficial asphyxia.'

Though the appearance of the patient under nitrous oxide may be in some cases rather suggestive of asphyxia, this is owing to undue air deprivation, or some constitutional dyscrasia of the patient, rather than the actual effect of the nitrous oxide gas.

It is hardly necessary to say that an anæsthesia produced largely by means of asphyxia would be extremely dangerous, and we know, both from

personal experience and from the vast number of cases recorded, that nitrous oxide is by a very long way the safest anæsthetic we possess. Paul Bert, while recognizing that the gas had a specific action on the tissues in producing insensibility, considered that the anæsthesia was accompanied by asphyxial phenomena, due to air exclusion, which he considered essential. Afterwards he discovered that anæsthesia could be produced even when air and oxygen were mixed with the gas.

More recently Dudley Buxton, Hewitt, and Bellamy Gardner conclusively demonstrated that:

1. Nitrous oxide enters into loose combination with the hæmoglobin of the red blood-corpuscles, and probably is so conveyed to the cells of the nerve centres.

2. It exerts a specific action on the central nervous system.

3. The phenomena of nitrous oxide anæsthesia are totally distinct from those occurring in asphyxia.

4. The effect of the nitrous oxide is stimulating on the circulation, particularly on the heart itself, except in so far as the introduction of any gas into the pulmonary circulation, if we exclude oxygen, increases friction, and so interferes in some degree with the circulation. That a mixture of air and

nitrous oxide, with a proportion not exceeding 30 per cent. of air, or a mixture of N_2O and oxygen, with not more than 12 per cent. of the latter, will produce a reliable and efficient anæsthesia.

Dudley Buxton well says: 'Nitrous oxide appears to suspend rather than extinguish vitality.'

Animals placed in irrespirable gases become convulsed before death; but when they are made to respire nitrous oxide, their respiration simply grows more and more shallow, and finally ceases without any of that *besoin de respirer* which is elicited when simple oxygen deprivation is practised.

Apparatus required in the Administration of Nitrous Oxide.

1. The cylinders for storing the gas.
2. The apparatus used for allowing the liquefied gas to expand and to convey it to the patient's respiratory passages.
3. Mouth-openers (Mason's gag), props, etc.

Nitrous oxide, immediately after being prepared and purified, is liquefied under very great pressure, and stored, as before mentioned, in very strong steel bottles or cylinders of various sizes. Those most commonly in use are the 25, 50, and 100

gallon sizes, weighing from 3 pounds 7 ounces to about 8 pounds 7 ounces respectively.

There are two patterns of cylinder:

The Angle Pattern.
The Ordinary Pattern.

The first named are now largely used, as they are more convenient for general purposes.

The figures on p. 50 illustrate the two bottles.

At B or B′ is a very powerful valve with the end squared so as to fit the pedal A or A′, by means of which the gas is turned on and escapes at the orifice C or C′ into a tube attached for conducting it into the gas-bag or gasometer.

Formerly the bottles were made of iron, but they are now made of steel, as when so constructed they can be made equally strong with much less metal.

There are a few practical points worth mentioning as regards storing of gas. When the bottles arrive they should be at once weighed to check the weights noted on the label fixed on the bottle by the maker.

They should be then stored in a box or cupboard, where the temperature is fairly equable, not near a stove or fire, and not in a place where they are likely to be knocked about or to fall.

If, when a bottle is being used for the first time,

the gas escapes in a slow and somewhat spasmodic manner, the bottle is probably *overfilled*, and frozen particles of liquid gas have escaped into the narrow exit and choked it. One may be mistaken and imagine the bottle empty, and if

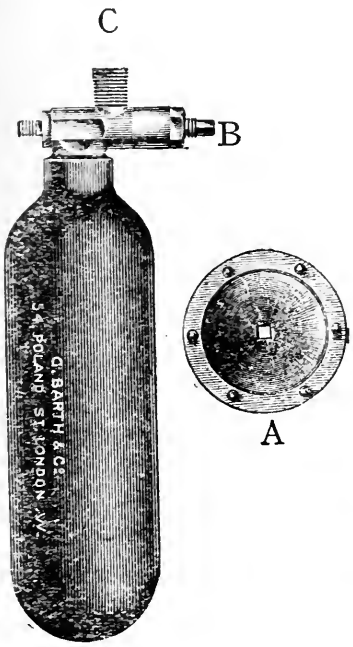

FIG. 7.—ANGLE PATTERN CYLINDER.*

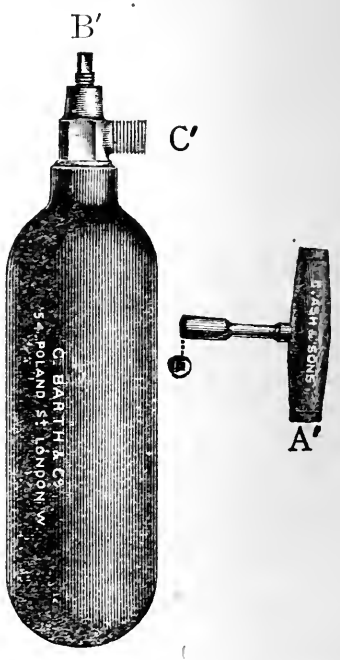

FIG. 8.—ORDINARY PATTERN CYLINDER.

it be put aside *turned on*, a somewhat alarming explosion will suddenly occur. The bottle should be taken off the stand, and kept slightly turned on

* Messrs. Barth's cylinders are fitted with a special arrangement to prevent moisture reaching the spindle (B) and causing corrosion and leakage.

while *warm* water is trickled *slowly over the neck* until the gas comes fizzing out.

If a considerable quantity of gas is used at a time, the bottle usually gets coated with hoar-frost, and then caution is needed in handling it to avoid a severe burn. It is convenient to have two angle bottles coupled on to a stand, and to use the same one until empty, so that if it becomes empty during an administration the other is always ready and may be turned on, while the empty one is replaced at a convenient opportunity.

Some bottles are very stiff in starting, and it is advisable to slightly loosen the valve with a wrench before commencing.

The foot-keys are made both in brass lacquered and nickel-plated steel, the latter being rather neater and less expensive.

In using them, the sole or heel of the boot, of the left leg usually, is firmly placed on the foot-key, and by rotating the leg to the left and outwards the valve is opened, and *vice versâ*. With a little practice the amount of gas escaping can be very nicely regulated.

After the administration is over, great care is needed to see the valve is very tightly screwed down, otherwise a very slight escape may go on, and on the next occasion the gas-bottle may be found completely emptied.

The gas may be administered (*a*) by means of a gasometer, or (*b*) by the modern nitrous oxide apparatus as made by Barth and Co., with 3-gallon bag and tubing, three-way stop-cock, and face-piece, and two 50-gallon gas-bottles on a stand.

(*a*) The nitrous oxide gasometer is really precisely on the same principle as that used for the storage of coal-gas. It consists of a metal reservoir sinking into a tank of water, and counterpoised by weights passing over pulleys.

The gas is introduced into the reservoirs by means of a tube connected with a large gas-bottle. If a gasometer is used, it is convenient to keep it in the room immediately beneath the operating-room, if possible, and by means of the tube passed through the flooring to a stand-pipe beside the chair to keep up the supply of gas. Or it may be kept in a cupboard, and moved out into the operating-room on castors when it is wanted.

The advantages of a gasometer are that:

1. The gas under a definite pressure is forced continuously and evenly through the tubes and face-piece.

2. If the valve of the gas-bottle is not, or for some reason cannot be, turned off completely, there is less waste, and the gas simply flows into the reservoir, and remains there under increased pressure.

The advantages, however, taking all things into consideration, are quite overcome by the tendency to get leaky, the clumsy nature of the apparatus, and the initial expense.

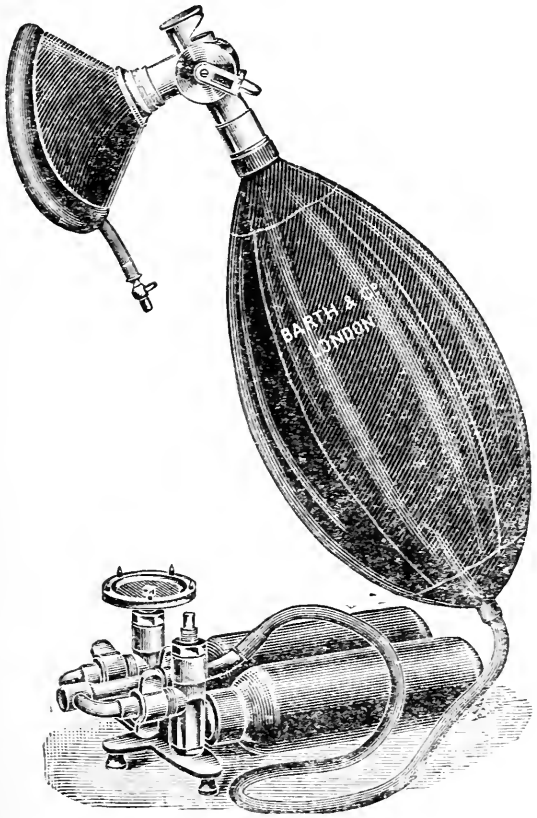

FIG. 9.—BARTH'S N_2O APPARATUS, WITH FACE-PIECE, THREE-WAY TAP, THREE-GALLON BAG, AND CYLINDERS.

(*b*) The latter method seems to find most favour in the eyes of the present-day dentist, for the apparatus is portable, cheaper than a gasometer,

and, on the whole, more economical of gas and less likely to get out of order, while the gas is always inhaled *fresh*, and anæsthesia more satisfactory.

1. Connecting the gas-bottles with the rubber tubing of the apparatus for administration is a metal union consisting of a tapering nozzle and a screw-nut for fixing it. Between the two a

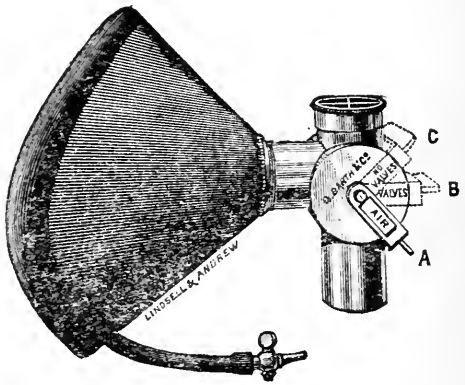

FIG. 10.—BARTH'S THREE-WAY STOP-COCK AND FACE-PIECE.

leather washer is placed so as to make the union absolutely hermetical.

2. The rubber tubing between this and the bag is about $\frac{1}{2}$ inch in diameter, stoutly made, and about 4 feet long.

3. The bag to which this is attached is an impervious rubber bag, made of high quality rubber, and not too thick, the capacity being about 3 gallons.

The best method of attachment is a simple vulcanite tap, so that, if it is desired to detach the bag from the tubing, this may be done, and, by turning the tap, any escape of gas is prevented.

To the upper end of the bag a three-way stop-cock is fixed, fitted with valves.

There are three apertures in the stop-cock: one opening into the gas-bag, one opening into the face-piece, and another opening to the external air directly or through valves, according to the position of the indicator. The stop-cock has three arms: one communicating with the face-piece; the second communicating with the gas-bag; and the third containing a simple expiratory flap valve.

At the junction of the three arms is situated the actual tap, which also contains a rubber 'flap' valve, and the movements of the tap are so arranged that on turning it more or less round we obtain:

(A) Communication between the face-piece and the external air alone, the bag being shut off.

(B) Communication between the face-piece and the gas-bag, both valves working; or, lastly,

(C) Communication between the face-piece and the bag alone, both valves being cut off.

Face-pieces :

(1) Leather and rubber sheeting.
(2) Compo and pad.
(3) Compo and glycerine.
(4) Celluloid and metal.

Whether the anæsthetic be gas, ethyl chloride, or ether, it is equally important to secure a good face-piece which does not allow of leakage.

To prevent this entirely may be a very difficult matter if the patient wears a large moustache or a beard, but with an ordinary clean-shaven face a properly constructed face-piece makes it quite easy.

The face-piece, despite the less degree of asepsis, should be in one piece. For those of metal or celluloid with a movable rubber pad we have no preference, but quite the contrary, as leakage is more likely to occur, and they are—the celluloid type, at any rate—more fragile and uncertain.

In our experience the best type of face-piece is made by Barth and Co., of a solid basis of rubber and leather compo with the inflatable pad fixed up with some adhesive substance.

This is very strong and lasts a long time; and while it cannot be boiled, it can be well soaked in antiseptic solution.

Next to that comes the type with the inner layer

of leather covered on each side with a layer of thin sheet-rubber.

The shape is important. The opening which

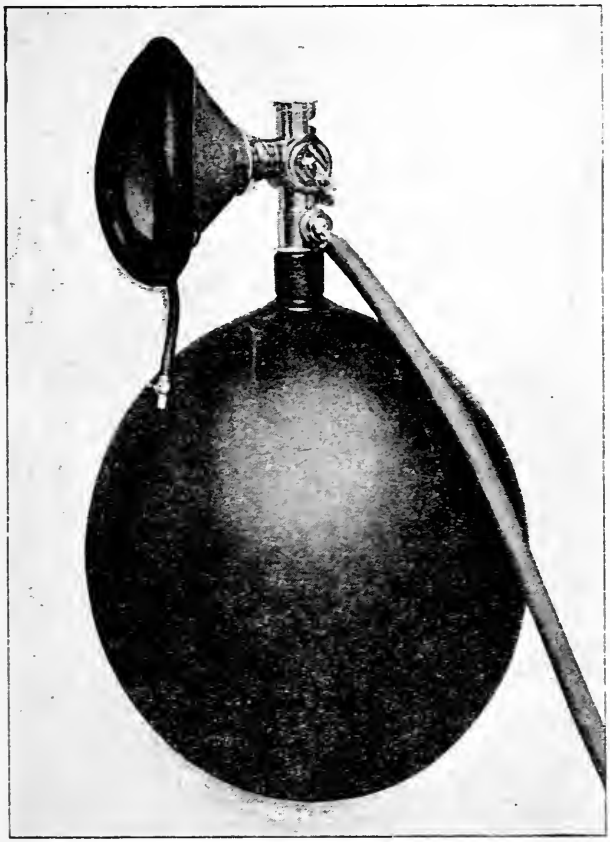

FIG. 11.—GUY'S ARRANGEMENT FOR NITROUS OXIDE.

fits over the patient's face should be an oblong with the greater breadth at the lower end. It should be neither round nor angular at the sides,

as one sometimes finds in foreign and cheap types.

The pad is usually inflated, but Arnold and Co. have put a face-piece on the market with the pad filled with glycerine, which seems a good idea.

If the apparatus is not being used fairly regularly, the indiarubber valves are apt to dry and curl up at the edges. This can be avoided by moistening them occasionally with a little warm water or weak carbolic lotion.

The Preparation of the Patient for Nitrous Oxide.

Little or no previous preparation in the way of fasting is necessary, but the gas should not be inhaled soon after a full meal. In all cases it is well to allow two hours to elapse between a meal and the administration. Prolonged fasting is, however, undesirable, and, indeed, increases any liability to fainting.

In spite of the extreme safety of nitrous oxide, it is distinctly desirable for the administrator to 'take stock' of the patient before undertaking the production of anæsthesia.

If the patient looks fit and robust, the dentist may merely remark that he assumes he has good health. If the patient is pale, anæmic or 'seedy' looking, he may go a little further, and inquire

as to any fainting fits, etc. *If there seems any doubt whatever as to the physical fitness of the patient, the ordinary medical attendant should be undoubtedly communicated with,* and certainly if such a wish is expressed, or it seems in any way desirable, his presence at the proposed administration secured. This will take much responsibility off the shoulders of the dentist in any case, and if anything untoward does happen, the medical man may afford valuable assistance.

In most medical schools students are now being taught to give gas along with other anæsthetics, so that the practitioner himself may be able to undertake the production of anæsthesia.

It is well, as before mentioned, especially when dealing with young children, to get the bladder emptied before putting them in the chair, and corsets should be removed or unlaced. The upper buttons of a coat or dress should be undone, and collar or brooch removed. Gloves, spectacles, hat, and artificial teeth are also to be removed.

Patients' friends are usually better out of the operating-room, but if they or the patient expressly desire it, they must be allowed to remain, and should be placed in such a position as not to be able to see the patient's face, which, when he or she is fully under the influence of gas, may be far from pleasing in appearance. In connection

with the subject, it is necessary to state that under no circumstances should gas or other anæsthetic be administered to a female without the presence of a third party, preferably one of her own sex, as charges of criminal assault, usually made in all good faith, are not uncommon.

The patient is now seated in the chair, and must be placed so as to suit both the requirements of the anæsthesia and the operation. He should be made to sit well back in the chair, the legs uncrossed and not too much flexed, nor pressed firmly against the foot-rest. This last is of special importance when the patient is tall, as opisthotonos, or arching of the back, will often occur when he becomes unconscious, so that he should be told to place his feet on the floor *beside* the foot-rest.

The head-rest must be brought well forward, and fixed firmly in such a position that the long axis of the patient's head is in continuation with the long axis of the body.

The importance of loose clothing during anæsthesia—whether induced by gas, gas and oxygen, or ether—is very great, in order to prevent any possible constriction of the upper respiratory passages, and to allow complete expansion of the lungs by diaphragmatic action.

If there are tightly-laced corsets or waistbands,

full descent of the diaphragm is interfered with, abdominal breaths cannot be taken, and the rapid exchange of the air in the lungs for the anæsthetic gas cannot be effected. If the operator particularly wishes the head somewhat thrown back, this should be effected after the anæsthesia has been established.

Before starting, the patient is asked to clasp his hands, or to firmly grip the arm of the chair (*not* of the operator !), and this is of especial value when dealing with nervous people.

Bellamy Gardner uses a belt or strap to hold the patient up in the chair.

The Effects produced by the Inhalation of Nitrous Oxide.

It is customary to divide the process of inducing and establishing anæsthesia into three stages:

First Stage.—The gas being turned on, the patient is at once conscious of the sweetish but not unpleasant taste which it possesses.

A feeling of warmth on the lips and an indescribable though not unpleasant numbness in the limbs is noted, while the patient has an irresistible desire to breathe more quickly and deeply. He then experiences a curious feeling of expansion and ' thrilling ' throughout the body. Ringing in the ears is common.

Consciousness is lost, however, in twenty to thirty seconds, almost before the patient has time to define his sensations, and the respirations deepen and become more regular.

The pulse is fuller, firmer, and somewhat quickened. The power of hearing persists during this stage, and, indeed, may become hyperacute, so that silence is very desirable.

Second Stage.—The patient is now unconscious, but not fully anæsthetized. Movement of the arms and legs is common, and this may be of an almost methodical nature—*e.g.*, beating rhythmically on the floor with the feet, or moving the arms as in rowing. These movements are known as 'occupation spasms.' Excitement is not usual if the gas be properly administered and air duly excluded. Vivid dreams are common, and may be rendered extremely unpleasant by commencing any operative procedure at this stage. Further, if an extraction be attempted, shouting and excitement will almost invariably occur. Erotic dreams and sensations are by no means uncommon, both at this stage and also later, when the patient is emerging from the anæsthesia.

Respiration is deeper and quicker than normal, and is regular in character. The pulse is full and more rapid than usual; the conjunctival reflex is still present. The pupils are gradually dilating,

and the complexion is growing dusky, the change being especially marked in people of fair complexion. The eyelids often twitch and become slightly separated.

Third Stage.—The respiration now loses its regular character, and a curious and characteristic 'snorting' sound or stertor becomes noticeable. This is owing to some obstruction of the air-way, due to spasmodic contraction of the elevators of the larynx raising it towards the epiglottis and base of the tongue. This stertor will be always more marked if the patient's head is at all extended, from the head-rest of the chair being too far back.

The pulse is more rapid in character, running up to 100 or 120 in the minute, but is somewhat less robust than in the second stage, and this is probably due to less blood reaching the left side of the heart.

The muscles may be quite relaxed, and the arms fall limply if raised by the anæsthetist, but some rigidity due to clonic or tonic spasm is more common if the gas is at all pushed. The spasmodic contractions are first noticed in the fingers, but they spread through the whole body, and may be so violent as to jerk the patient out of the chair. These movements are commonly known as *jactitation*.

The facial muscles are in some cases more

affected than any, and the appearance of the patient is then usually extremely unpleasant. Sometimes the *erector spinæ* muscles are chiefly affected, and then the phenomenon *opisthotonos* is seen, the patient's back forming a complete arch, while he is merely supported by his heels on the foot-board and his head on the head-rest. This very awkward development usually disappears on lightening the anæsthesia by giving air or oxygen.

Micturition and the passage of flatus, or even fæces, may occur in this stage, particularly in children. Accordingly, it is well to get a young patient to empty his bladder before giving nitrous oxide.

The pupil is now usually well dilated, conjunctival reflex gone, but this is not always the case.

The facial expression is usually considerably distorted, the eyeballs rotate in an unpleasant manner, and fat people of the apoplectic type become markedly cyanosed.

The Administration.

Before adjusting the face-piece, it is necessary in the large majority of cases to insert a mouth-prop (such as described previously). Care must be taken that it lies quite straight and firmly in the bite. It should, if possible, never be placed further forward than the bicuspid teeth, or the

masseteric spasm set up during anæsthesia may be so great as to force the incisors or canines out. If it be far forward, place it between the incisors, and see that the prop is sufficiently broad to impinge on the surface of the two teeth.

In some cases where there is an alveolar abscess it may be quite impossible to open the mouth sufficiently to insert a prop. In such cases the administration may be gone on with, and, when the patient is under, the mouth may be opened by means of a wooden wedge or Heister's screw-gag.

The face-piece having been adjusted with the pointer of the stop-cock turned to 'Air,' the patient is instructed to breathe quietly to and fro (not to take deep breaths), and the pointer turned to 'Valves.' The gas is now breathed in from the bag through the inspiratory valve into the mouth and lungs of the patient, and expired, mixed with CO_2, etc., through the expiratory valve.

This may be continued for eight or ten breaths, when the pointer may be turned right on to 'No valves,' and to and from breathing be permitted until anæsthesia is induced. The bag should not be allowed to become distended, but be kept full, so that the gas is administered rather above the atmospheric pressure.

Care must be taken throughout to avoid any

leakage around the face-piece, which is particularly apt to occur around the upper part.

It may be necessary in some cases to exercise a little pressure here by means of the forefinger and thumb of the left hand.

Recovery from the Anæsthetic.

From the moment of the removal of the face-piece, the degree of narcosis lightens, and anæsthesia passes into analgesia, with excitement. The pulse, which has been increased in rapidity and tension, returns to its almost normal rhythm with the first good inspiration, lips and skin regain their normal hue, stertor and jactitation disappear, and the respirations become quick and shallow or panting.

The conjunctivæ lose their congested appearance and regain their tactile reflex. The patient feels somewhat dazed, as when awaking from a deep sleep, but rapidly regains complete consciousness, and complains of no ill-effects.

As soon as the extraction is complete, the head and shoulders of the patient should be drawn well forward, and so blood prevented from getting into the larynx and causing cough and irritation. If the patient is somewhat slow in coming round, provided colour and breathing are good, no vigorous efforts should be made to awake him,

and if a prop has been inserted into the mouth, it should be left alone until the patient is quite conscious, otherwise the forcible removal of it will give him a strong impression, most difficult to eliminate, that it was the removal of the tooth that he felt.

When the mouth has been thoroughly washed out and the hæmorrhage has stopped, the patient may be allowed to sit back in the chair a few minutes before rising, as the power of locomotion is at first somewhat impaired. He or she may then be allowed to go to another room for a further ten minutes' rest, or at once to a cab, without any fear of ill-effect.

Time taken to induce Anæsthesia—Duration of Anæsthesia.

There seems to be a considerable discrepancy of opinion on these points. Sir Frederick Hewitt found the average time occupied in producing full anæsthesia is 55·9 seconds when dealing with a fairly robust, fully-developed adult. Silk gives it as 67·5 seconds, and the committee of the Odontological Society 73 seconds. Hewitt found the usual available anæsthesia to be 30·3 seconds, while the Odontological Society found it to average 24·7 seconds only.

Children and feeble anæmic subjects become

rapidly cyanosed and stertorous with nitrous oxide often in about 20 seconds, but the length of the anæsthesia is usually correspondingly short.

It is, of course, very difficult to decide when the true anæsthesia terminates. The period of anæsthesia, however, depends to a considerable extent on the duration of the inhalation, a long inhalation usually affording a long anæsthesia, and *vice versâ*.

Further, the available anæsthesia may be prolonged for some seconds by allowing a breath of air at every fifth respiration during the induction of anæsthesia. This fact was pointed out by the late G. Rowell; he usually commenced allowing air after the patient had had about fifteen breaths of pure gas.

After-Effects of Nitrous Oxide.

The after-effects of nitrous oxide are usually exceedingly slight and transient; indeed, there is no known anæsthetic which produces less constitutional disturbance.

Slight headache and vertigo, accompanied by a feeling of lassitude and depression, are occasionally seen. If at all marked, some impurity in the gas may be suspected, or the administration may have been faultily conducted, and too much CO_2 inhaled along with the nitrous oxide from rebreathing; or some blood may have been swallowed.

If the patient has had a meal within the last two hours, these symptoms are more prone to occur, and may be accompanied by nausea and even active vomiting. Accordingly, it is well before administering to inquire when the last meal was taken. Pallor and faintness are due usually to stomachic disturbance and threatened vomiting rather than to any direct circulatory disturbance.

Two administrations at a sitting can rarely be carried out without causing a good deal of after-discomfort and headache, and should therefore not be undertaken unless the patient lives at a distance and it is especially desirable to complete the extraction.

The author has on several occasions seen a sort of cataleptic condition follow a gas administration

Continuous Administration of Nitrous Oxide.

During the last ten or fifteen years many attempts have been made to administer nitrous oxide in a more or less continuous manner, so as to produce and maintain an anæsthesia suitable for prolonged dental extraction, and even for surgical operations.

Several of the last named, of a duration of an hour or more, have actually been done with nitrous oxide anæsthesia kept up by intermittent administration of the gas by the ordinary apparatus. It will be obvious to those acquainted

with the ordinary phenomena of nitrous oxide anæsthesia, however, and the quietness of breathing and muscular flaccidity essential to the performance of the majority of the operations of surgery, that the gas is by no means adapted for such use. On the other hand, for dental work it always has been, and probably always will be, the most popular and best-adapted anæsthetic.

Some of the methods employed to obtain a prolonged anæsthesia only require a very brief notice. Coxon used a metal tube to convey the gas into the mouth, and, having produced anæsthesia in this way, he maintained it during the extraction by keeping up a continuous stream of gas.

Harvey Hilliard first induced anæsthesia by the ordinary face-piece, and then kept up the supply of gas through a nasal tube. This latter the author considers distinctly objectionable, for it is apt to cause considerable epistaxis. Further, if there be any adenoid growths or nasal obstruction, it cannot be used.

Coleman in 1899 brought out yet another apparatus, which consisted of a nose-piece attached to the gas-bag by a tube, and when in use fixed by a kind of clamp arrangement to the patient's head. Bearing in mind the varieties of fashions which ladies affect in wearing their hair, the difficulty of making any one fixative clamp generally adaptable at once suggests itself.

This apparatus, however, has been the basis on which recent improvements by H. J. Paterson and others have produced a thoroughly reliable and useful means of keeping up continuous gas anæsthesia. For supplying the gas Paterson uses the ordinary two-bottle gas-stand with nozzle attachment. To this is adapted a $\frac{1}{2}$-inch rubber tube, which enters a small 2-gallon rubber bag to which is fixed a two-way stop-cock. From the stop-cock pass two narrow, very flexible rubber tubes, which pass to supply a metal nose-piece fitted with rubber air-pad to admit of very accurate adaptation to the patient's nose and face. Having filled the bag about two-thirds full of gas, a mouth-prop is inserted, the nose-piece carefully adjusted, and the stop-cock turned on.—A stream of gas now passes into the nasal passages during each inhalation. The patient thus breathes nitrous oxide through the nose and a variable quantity of air through the mouth. If, however, anæsthesia is slow in being established, a celluloid mouthpiece is provided, with an expiratory valve only, and this is carefully adapted to the mouth to prevent any air entering, while still allowing the patient to expire. In 75 per cent. of cases anæsthesia may be completely established in forty to fifty seconds without any use of the mouthpiece. If this is used, however, less time will be needed. The patient becomes only slightly dusky, and any

stertor or cyanosis is readily removed by stopping the supply of gas, and turning the tap of the two-way stop-cock so as to lie horizontally. In good types of patients who are not nervous or alcoholic, it is quite possible to keep up a safe anæsthesia almost indefinitely—at any rate, for ten to fifteen minutes—long enough for a moderately dexterous operator to ' clear a mouth.'

It is often necessary to keep a good deal of pressure on the gas-supply, with the bag distended, to keep the patient well anæsthetized. For ten minutes' anæsthesia 30 to 40 gallons of gas will be necessary.

On recovery from the anæsthesia patients are usually very fresh indeed, any disagreeable after-effects being usually due to swallowed blood. There is a marked contrast in the condition of the patient after continuous gas anæsthesia and gas and ethyl chloride, or ethyl chloride alone.

Paterson's apparatus has the disadvantage of having only one size of nose-piece, which is made of fairly thick white metal, and is thus by no means readily adaptable to the large variety of noses which we find in the human species.

Nash, of Ayr, recognizing this drawback, has made the nose-piece in several sizes of thin, pliable copper plate, and has effected a great improvement. He has also supplied the nose-piece with an expiratory valve, which modifies the

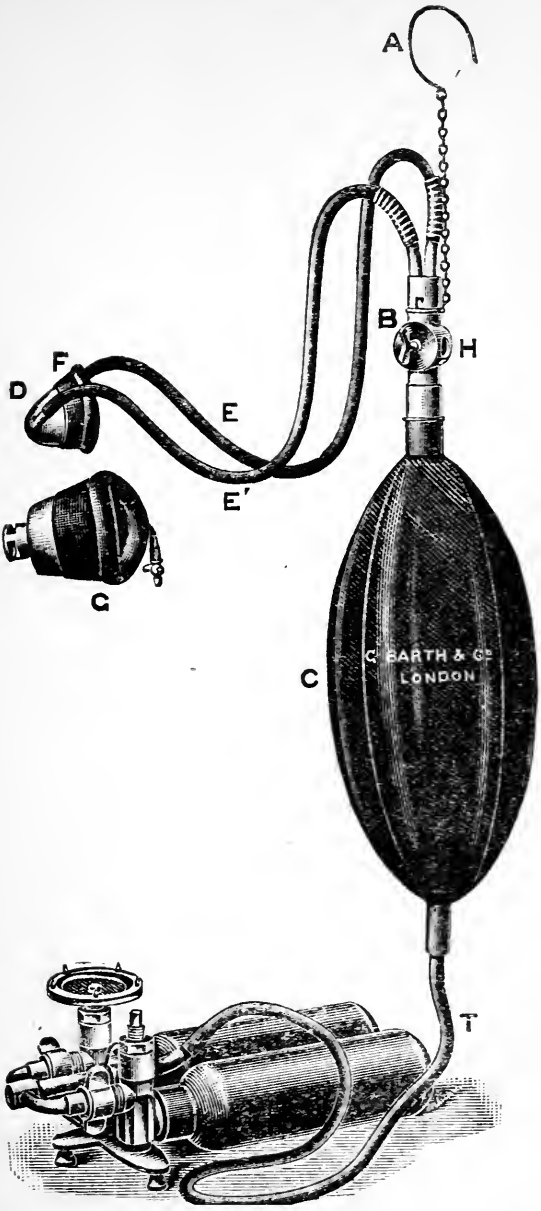

FIG. 12.—PATERSON'S APPARATUS

technique in this respect, that instead of telling the patient to ' Breathe in through the nose and out through the mouth,' one simply directs him to ' Breathe to and fro through the nose.'

Advantages of the Nasal Method.

It is a quick and safe method of obtaining one to ten minutes' anæsthesia, but especially useful where only two or three minutes' anæsthesia are wanted, for the removal of four temporary molars, two or three roots, or any procedure requiring rather more than the time obtained when gas is given by the ordinary way. The patients are able to leave the dentist's room almost immediately, nausea and vomiting being extremely rare. In this respect the method compares most favourably with ethyl chloride or ' gas and ethyl chloride,' and there is no unpleasant smell or taste to complain of.

Disadvantages.

Unless the dentist has a capable assistant who can either act as anæsthetist or operator, the apparatus cannot be used without outside assistance. Further, a third person is almost needed to sponge and change the mouth-props if necessary, or insert a Mason's gag. Considerable skill and practice are needed to use the apparatus efficiently,

while the risk of overdose from nitrous oxide, if air be not duly supplied from time to time, is of course increased.

As Bellamy Gardner points out, the great advantage of the nasal apparatus for systematic induction of N_2O anæsthesia is that we never need charge the patient up with the gas. We may divide full N_2O anæsthesia when there is stertor, lividity, and jactitation into, say, ten degrees. If we are giving the gas nasally we need only reach, say, the fifth degree, when the patient is ready, and all we have to do is to keep him anæsthetized and maintain a good colour.

After being in use for some time the elasticity of the bag decreases, and it is often necessary to get a new bag or to maintain the pressure by keeping the bag between the dental chair and the anæsthetist's knee, but this is readily done.

Lastly, the cost of the often considerable amount of gas used is too great to admit of this method being much used except in good-class private practice.

When young children from seven to twelve are kept under gas for any time screaming and crying out are very common. It is a great drawback if friends are present, as it is difficult to persuade them nothing has been felt, although the child may regain consciousness with a smile.

Details of 100 Cases of Anæsthesia produced by Continuous Administration of Nitrous Oxide.

Average anæsthesia, 2·84 minutes.
Average time for induction, 35 to 40 seconds.

No.	Sex.	Age.	Duration of Anæsthesia.	Extractions.	Remarks.
			Minutes.		
1	F.	14	5	12	Noisy. Thirty gallons gas used.
2	F.	54	1	7	Patient very feeble.
3	F.	26	4·5	5 stumps	Hypnotic condition afterwards.
4	M.	19	3	3 stumps	
5	F.	14	1	4 temp. molars	
6	F.	17	5	17 teeth	Very fresh afterwards.
7	F.	35	2·5	6 ,,	Opisthotonos.
8	F.	30	5	16 ,,	Excellent colour.
9	M.	28	4	4 stumps	Powerful man.
10	F.	28	4	2 ,,	Very good colour.
11	F.	23	1·5	8 teeth	
12	F.	10	3	4 temp. molars	Very refractory child; started with ordinary face-piece, and changed to Paterson after.
13	M.	22	3·5	3 stumps	Some cyanosis.
14	M.	9	3	3 ,,	
15	F.	35	2	2 ,,	Mitral stenosis; feeble patient.
16	F.	24	2	12 teeth	Screaming.
17	M.	20	1·5	1 very bad stump	
18	M.	9	3	2 stumps	
19	F.	35	3·25	4 ,,	
20	M.	12	4	4 temp. molars	
21	F.	32	3	16 teeth	
22	F.	27	2	2 stumps	
23	F.	12	2	1 very bad stump	
24	M.	45	2	3 teeth	Alcoholic; violent struggling and phonation. Broke arm off chair.
25	F.	20	2	3 ,,	
26	F.	30	2	1 root	

Details of 100 Cases of Anæsthesia (*contd.*).

No.	Sex.	Age.	Duration of Anæsthesia.	Extractions.	Remarks.
			Minutes.		
27	M.	23	3	1 very bad root	
28	F.	25	1	1 very bad root	
29	F.	32	0·75	1 tooth	Seventh month of pregnancy; very delicate. No cyanosis or jactitation.
30	F.	45	3	8 teeth	
31	F.	34	1	2 ,,	
32	F.	30	5	13 ,,	
33	F.	30	4·5	12 stumps	
34	F.	27	1	1 stump	
35	M.	44	1·5	18 teeth	
36	F.	19	3	8 ,,	
37	F.	35	3·5	12 ,,	
38	M.	44	2·5	10 ,,	
39	F.	26	3	13 ,,	
40	M.	62	3·5	5 ,,	Very acute gum-boil upper lip. Nose-piece changed to large face-piece.
41	M.	10	2·5	4 temp. molars	
42	M.	18	3·5	10 teeth	
43	F.	26	3	10 ,,	
44	F.	35	2	4 ,,	
45	F.	32	1	2 ,,	Nervous. Opisthotonos. Shaky afterwards.
46	F.	32	1·5	5 roots	
47	M.	48	2	2 stiff molars	Opisthotonos and stertor.
48	F.	30	5	19	Phonation; very fresh after.
49	F.	32	3	3	Noisy. Opisthotonos.
50	M.	54	2	12	Very robust patient.
51	M.	18	8	16	
52	F.	28	10	18	
53	F.	19	4·5	12	Excellent colour.
54	M.	12	4	5	Two administrations; vomited; three hours since food.
55	F.	15	2·5	4 stumps	Very good colour.
56	F.	24	5	15 ,,	
57	F.	26	2·5	4 ,,	
58	F.	18	3·5	8 teeth	
59	F.	29	5·5	29 ,,	Very fresh after; walked home.

Details of 100 Cases of Anæsthesia (*contd.*).

No.	Sex.	Age.	Duration of Anæsthesia.	Extractions.	Remarks.
			Minutes.		
60	F.	34	1·5	12 teeth	
61	M.	23	7	29 ,,	
62	F.	27	6·5	25 ,,	
63	F.	21	2	4 roots	
64	M.	17	2	8 ,,	
65	F.	20	1·75	17 teeth	Patient very pleased.
66	F.	13	1·5	4 ,,	Temporary molars.
67	F.	30	2	8	
68	F.	33	3	4	One a very bad stump.
69	F.	29	3	7	
70	M.	28	2·5	9	
71	F.	23	2	3 roots	Deaf-mute.
72	F.	38	2·5	5 ,,	
73	F.	28	1·75	3	
74	F.	50	1	1 root	
75	F.	13	1·3	4	
76	M.	21	2	4	
77	F.	35	3	(Antrum case)	Patient very cyanosed. High colour.
78	F.	13	1·5	4	Temporary molars.
79	F.	38	3	1	Very bad stump.
80	M.	12	1·25	4	Temporary molars. Loud phonation; awoke smiling.
81	F.	22	5	9 teeth	Three pulps were also drilled out.
82	F.	27	1·5	2 roots	
83	M.	35	3	1 root	A very stiff root.
84	M.	20	3·5	9 roots	
85	F.	30	1·25	3 ,,	
86	M.	35	1	5 teeth	Marked opisthotonos; stopped administration.
87	M.	38	9	12 ,,	Forty gallons N_2O used.
88	F.	28	3	10 ,,	Opisthotonos.
89	M.	30	1·5	3 roots	
90	M.	24	1·5	1 root	
91	F.	66	1·25	4 teeth	
92	F.	35	1	1 root	
93	F.	45	1·5	5 teeth	
94	F.	40	1	4 ,,	
95	F.	28	8	18 ,,	
96	F.	30	3·5	5 roots	
97	M.	28	4	7 teeth	Noisy.
98	F.	48	2·5	8 ,,	
99	F.	39	2	3 ,,	
100	M.	24	2	3 ,,	Opisthotonos.

CHAPTER IV

ETHYL CHLORIDE (C_2H_5Cl)

ETHYL CHLORIDE, first employed by Heyfelder, is a colourless, highly volatile liquid of aromatic odour and sweetish taste and neutral reaction. It volatilizes at all ordinary temperatures without leaving any residue, but if at all decomposed gives off a slightly garlicky odour from the skin when evaporated on the palm of the hand. It has a density of 0·92 at 0° C., and the density of the vapour, taking air at unity, is 2·3. It boils at 12·5° C.

It is very readily soluble in alcohol, but sparingly so in ether. The drug is very combustible, burning with a green flame and setting free hydrochloric acid. It is manufactured by subjecting a boiling solution of chloride of zinc (in alcohol) to the action of hydrochloric acid. When put up in cylinders holding from 50 to 60 c.c., it shows no tendency to decompose or undergo chemical change even when exposed to light. Its purchase in larger bulk than this is not to be advised, except to those who are skilled chemists and accustomed

to handling very volatile substances. Ethyl chloride has a solvent action on various substances, but no appreciative action on rubber sheeting, any more than sulphuric ether. It will, however, rapidly destroy vulcanite stop-cocks.

In spite of its extreme volatility, if a few c.c. be decanted into a small test-tube of thick glass no considerable amount of the drug will be lost, even if the tube be exposed for from five to ten minutes in a room at 70° F. But the tendency to ebullition is very marked if a small particle of glass or metal be dropped into the tube.

Apparatus for administering Ethyl Chloride.

While various methods have been suggested for administering the drug, and patients have been and can be anæsthetized by open methods, one has no hesitation in saying that the only satisfactory method is the closed method with some type of bag inhaler. It should be simple in design and have a wide bore. Merely to render a patient unconscious or semi-anæsthetized as a preliminary to ether or chloroform anæsthesia the drug may be given on a handkerchief folded into the form of a cone, or a piece of lint with jaconet over it. Indeed, when dealing with nervous and excitable people or children, this may be even

advantageous, but where a full anæsthesia is required it is useless.

In detective stories we read of the magical way in which a few drops of chloroform on a handkerchief serve to render the hero or heroine unconscious while the villain of the piece works his nefarious will. Everyone who has the slightest acquaintance with chloroform and its action knows this to be absurd, but with a lavish use of ethyl chloride something of the kind might be effected.

As regards closed inhalers, the essential parts are—

(1) A good face-piece with a pneumatic pad.

(2) A rubber bag of 1-gallon capacity.

(3) A metal angle junction tube with an aperture at one aspect, or another through which the ethyl chloride may be introduced. Or alternatively, as in Guy's apparatus, the mount may be fitted with a two-way stop-cock.

In the interests of accurate dosage, it is a good plan to have a small piece of rubber tube extended from the bottom of the bag, to which is then attached a glass test-tube capable of holding about 5 c.c. of ethyl chloride, into which the drug is carefully measured. This test-tube should be marked at 3 c.c. and 5 c.c. By means of it an absolutely definite quantity of ethyl chloride can

be administered as the initial dose, and if there be any need to use more (in the large majority of cases there is no need), it may be added by means of the aperture in the angle-tube. In Guy's inhaler, which is shown on p. 152, there is some little difference in actual structure, although the principle is essentially the same. The apparatus is slightly more complicated. He uses a Barth three-way tap, which carries a feed-tube mounted on a ball-and-socket joint. Through this tube gas or ethyl chloride is introduced into the bag. Fig. 18 shows the arrangement. A hole is made halfway up the upper part of the bag-mount; the feed-tube mounted in its ball-and-socket joint is continuous with the hole. In the perpendicular arm of the three-way tap a corresponding hole is made; a pointer on the bag-mount and an arrow-head on the perpendicular arm of the tap serve to show when the two holes are in apposition. As an additional convenience, another hole is made exactly opposite, so that gas or ethyl chloride can be introduced on either side.

Guy has a special glass measure with a base on which it can readily stand. To use this inhaler for ethyl chloride alone, the drug is sprayed into the measure, which is then attached to the tube; the tube should be adjusted in its most dependent position. The pointer of the tap

is put at 'No valves,' the face-piece being adjusted to the patient's face; the feed-tube is raised, and the ethyl chloride slowly tilted into the bag. This apparatus can be equally well adapted for the administration of gas, or gas and ether, etc.

It will be seen, then, that to make a thoroughly satisfactory inhaler for ethyl chloride we have to only slightly modify the parts of an ordinary Clover's inhaler, having put the ether chamber aside. The modifications are such that any instrument-maker can carry them out at a trifling cost; and this is a point of some importance, as many dental and medical practitioners already possess a Clover's inhaler. No part of the inhaler should be made of vulcanite, owing to the tendency of this to perish under the action of ethyl chloride. Either red or black rubber will do for the bag and face-piece, but on the whole the red rubber lasts longer.

McCardie and Harvey Hilliard have advocated the use of an Ormsby inhaler for ethyl chloride, and the writers agree that it answers well, although he prefers to use one of the inhalers already described as being better adapted for accurate dosage. The construction of special inhalers for the administration of ethyl chloride is to be deprecated, for there is no necessity for them, and they lead to confusion and bad results rather than otherwise.

There have been an endless number of them placed on the market from time to time, especially when the drug first came into vogue, but their multiplication is more calculated to further the commercial interests of the instrument-maker than to be of any service to the profession at large.

We consider the employment of lint or small sponges in closed inhalers not only unnecessary, but actually disadvantageous. Lint and sponge almost invariably freeze, and render the induction of anæsthesia unduly slow. Ethyl chloride sprayed into the bag in quantities of 5 to 8 c.c. rapidly vaporizes, and does no harm to the rubber of the bag or face-piece.

Rebreathing.

A word may be said here about rebreathing. Wherever a closed form of inhaler is used, be it a Clover or gas or gas and oxygen of one type or another, a certain amount of rebreathing at times is allowed and may be desirable. Æsthetically there are certainly objections to reinhaling one's own exhalations, but one has to remember, as Flagg points out, that our ordinary respirations under even modern housing conditions involve a good deal of rebreathing. Flagg states that with the total vital capacity of the lungs put at 3,700 c.c., only about 500 c.c. is, as a rule, actually fresh

air with ordinary quiet respiration. Under such circumstances we rebreathe more than six-sevenths of the air which we use for respiratory purposes. Rebreathing from a bag is, therefore, relative rather than absolute difference. Disagreeable effects from CO_2 are rather due to an absence of oxygen—anoxæmia—than to the CO_2. Five per cent. to six per cent. of CO_2 temporarily with adequate oxygen produces little, if any, harmful effect in all probability.

It is not generally understood that cyanosis has nothing to do with the amount of CO_2 in the blood. The gas usually exists in the blood in simple solution and in chemical combination with alkalis present. The colour of blood is dependent on the corpuscles and the amount of Hb contained in individual cells. The controlling element is really the hæmoglobin, and when it is exposed to oxygen, oxyhæmoglobin is formed, giving blood its characteristic hue. Duskiness is due to reduction of the oxyhæmoglobin, and further reduction will cause lividity. Flagg holds that rebreathing may even be beneficial in a long anæsthesia, in that the presence of CO_2 in the blood-corpuscles increases the frequency with which the Hb parts with its oxygen and promotes oxygenation of the vital tissues.

Probably carbon monoxide (CO) is confused

with CO_2 by some people, and, as is well known, this gas forms a very close combination with Hb, excluding oxygen and causing early death from anoxæmia.

Preparation of the Patient.

The patient should have abstained from food for a period of not less than two hours prior to the administration of ethyl chloride. If the stomach, rectum, and bladder be not empty beforehand, they are very likely to empty themselves reflexly during or after the anæsthesia, and this is particularly so in children.

If there be any dentures present in the mouth they should be removed, and anything tight about the neck or corsets should be loosened or taken off. It is a wise precaution in all cases to have heart and lungs examined by the patient's ordinary medical attendant, not so much from the liability of disease being present such as would contra-indicate the use of ethyl chloride and indicate another anæsthetic, but as a means of establishing the patient's confidence and being prepared for any eventuality.

Posture of the Patient.

There is no contra-indication whatever to the sitting-up posture, unless the operator prefer the

lying-down position; this position is often more suitable for young children, as they are apt to slip down in the chair and collapse in a heap, to the embarrassment of all concerned. When the sitting-up position is utilized, however, the head must not be put too far back, for if this be done the trachea becomes pressed upon by the neck muscles, and the respiration gets embarrassed. The coronal plane of the head should be in the same vertical as is the spinal column.

The Administration.

The ethyl chloride having been accurately measured, the face-piece is carefully adjusted and the patient told to breathe away quietly to and from the bag. Whether the ethyl chloride be introduced into the bag from a graduated test-tube or directly, it is well to do this gradually, as otherwise the vapour may be too pungent and cause the patient to hold his breath. After about six to eight full breaths the respiration becomes deeper, and the pupils contract somewhat, but they then almost immediately begin to dilate and lose their reaction to light. The pupil is dilated in 40 per cent. of cases, contracted in 8 per cent., and practically unchanged in 52 per cent. (Reboul).

The eyes become fixed in one axis, and the con-

junctival reflex is lost. It is important not to push the anæsthetic after this happens, or until the cough reflex disappears, as there is considerable risk of solid matter getting down the air-passages.

The muscles become relaxed, as a rule, throughout the body, with the exception of the masseter muscle, which very often goes into spasm. This constitutes one of the drawbacks to the drug, and to avoid waste of time in opening the mouth the use of a mouth-prop inserted prior to the commencement of the inhalation is desirable, just as in the case of nitrous oxide gas. The pulse is full and bounding, and if a sphygmographic tracing be taken it shows a clearly-defined tidal wave. The patient's face is flushed, and sometimes beads of perspiration appear very soon on the forehead. Unconsciousness supervenes in from 18 to 25 seconds, and on the average a full anæsthesia is obtained in 50·9 seconds, allowing an available period for operating of 71·3 seconds (McCardie). The writer has found, however, that where a longer period than this is desired, it can be obtained without difficulty by pushing the drug somewhat, although at all times caution is necessary in this respect.

As regards the stages of anæsthesia, Malherbe and Laval described the following:

1. An analgesic stage, which commences after

two or three breaths of the anæsthetic and lasts thirty seconds or thereabouts.

2. An anæsthetic stage, which lasts from two to three minutes.

3. A second analgesic stage, during which the patient may move and talk, but feels nothing.

Any trouble that the authors have had with ethyl chloride has been respiratory in character. Cyanosis and spasm of the chest muscles comes on in certain subjects, especially muscular males, with alarming rapidity, but is not serious if the anæsthetist keep his head.

If a wedge or gag be not in the mouth, one must be inserted at once, and a free air-way established by means of traction on the tongue, etc., and artificial respiration applied, which, with the withdrawal of the anæsthetic, usually rapidly restores the patient's respiratory equilibrium and normal colour.

After-Effects.

The after-effects vary considerably in different subjects. They are also, of course, affected by the length of the administration.

Vomiting is the most common and most unpleasant sequela, occurring in 15 to 20 per cent. of cases, and nausea in a greater percentage.

As regards the character of the sickness, it re-

sembles that which is seen after ether anæsthesia, violent while it lasts and of short duration. It is often over in fifteen minutes, and anything longer than three to four hours is quite exceptional. McCardie records one case of thirty hours. As noted elsewhere, sickness and nausea are much less common when nitrous oxide or oxygen are given along with the ethyl chloride.

The writers find that sickness occurs more often among private patients than in hospital, but Harvey Hilliard finds the contrary to be the case.

A great deal depends on the manner in which the patients have been prepared, and, in short, whether they have had a meal recently or not. Patients who have come from a distance and who are anæsthetized late in the day are more commonly upset than those who are dealt with in the morning after a light meal taken early.

Hysterical symptoms are fairly common with young girls, associated with profuse lachrymation on regaining consciousness.

The drug has a distinct tendency to promote erotic thoughts and dreams, and even sensuous movements of the patient's limbs, etc., while in the semi-anæsthetic state. Subsequent accusations by females of indecent assault have been recorded. Marshall of Liverpool mentions two such cases and McCardie another.

Fainting and collapse are seen at times, but are usually associated with vomiting, etc. Jaundice is uncommon as a late sequela, but some cases have been noted in Paris. Albuminuria is unknown in healthy people, except after prolonged narcoses of half an hour or more. Fatty degeneration of the liver and kidneys has been noticed after repeated administration.

General Conclusions as regards Ethyl Chloride for General Anæsthesia.

1. It is rapid and pleasant in action, and a very portable substance.

2. As regards period available for operative procedure, it compares very favourably with nitrous oxide, always remembering it is much less safe in all subjects.

3. It causes little or no cyanosis under ordinary circumstances. If this is noticeable it is either due to excessive rebreathing or to commencing respiratory spasm.

4. The administration is very simple in technique.

5. The drug is safer as an anæsthetic agent than ether, ethyl bromide, or chloroform.

6. It can be readministered at a sitting, thus having an advantage over ethyl bromide.

7. Although vomiting is fairly frequent, it is not followed by any severe after-effects.

8. It is cheaper than nitrous oxide, and, of course, infinitely more portable and convenient in the country.

9. It is to be preferred to nitrous oxide in very young subjects, in the anæmic, for alcoholics in whom N_2O has very little effect, and for those who smoke to excess. For some of these cases a combination of nitrous oxide with the ethyl chloride may be desirable.

10. The somewhat sickly odour is objected to by a few patients, but may be disguised by a little perfume.

11. While in certain subjects the degree of after-sickness is a serious drawback (modified by adequate preparation), and the indiscriminate and haphazard manner in which ethyl chloride was administered all over the country by unqualified and irresponsible persons threatened at one time to bring the drug into disrepute from the occurrence of a considerable number of fatalities, we are of the opinion that ethyl chloride administered skilfully with all due precautions is a safe and in many ways admirable anæsthetic. For some reason it hardly ever gained the appreciation in London which it has acquired in the provinces and abroad, but that it is now largely

used with advantage where formerly either chloroform or ether would have been considered indispensable there is no doubt. It must be put into a quite different category, however, from nitrous oxide as regards safety.

It should be avoided in old people except for very brief anæsthesias; it should not be given to asthmatics or bronchitics or to those with established kidney trouble. There is special danger in advanced pregnancy, the very obese, or those with large abdominal tumours, and in any condition involving constriction of the air-passages: all for the same reason—viz., that respiratory difficulties are specially liable to arise here, and the trouble we have with this drug is usually respiratory rather than circulatory.

CHAPTER V

ETHER

ETHER was probably discovered chemically by Michael Faraday, but Crawford W. Long first used it as an anæsthetic in 1843. He appears to have not thought very much about it, however, as he left it to Morton to claim the credit some three years later.

Ether is a very volatile, highly inflammable liquid devoid of colour, but with a peculiarly characteristic odour and hot taste. It contains about 8 per cent. of spirit, and boils at 100° F. The specific gravity varies slightly, according to the purity, the range being ·720—·735.

Crude methylated ether is unsuitable for anæsthetic purposes, but good ether can be prepared from it, known as 'æther purificatus.' Ether prepared from pure ethylic alcohol is really unnecessarily expensive when this variety can be obtained.

For dental purposes the open method of ether need hardly be considered. In a case of very

severe toothache for the time incurable, except by extraction, a dental surgeon might suggest the inhalation of a few drops of ether on a handkerchief as an analgesic, but it is quite out of count for operative purposes. The semi-open method is almost as much so, leaving us merely the closed method to consider.

The Closed Method.

The essential ingredients in the closed method are (1) a good face-piece; (2) some closed chamber of varying type for containing the liquid ether; and (3) the ultimate bag (1 gallon) from which the patient inhales the mixture of ether and air in varying percentage.

Several inhalers conform to these requisites. Ormsby's, Clement Lucas's (with a simple glass chamber and contained sponge), Bellamy Gardner's, Hewitt's, and Clover's.

For all practical purposes we may eliminate the first three, as for one occasion on which they are used Clover's is used fifty times and Hewitt's five times at the very least.

Clover's inhaler was brought out in 1877, and has been *facile princeps* ever since. While the wide bore in that devised by Hewitt has an advantage in allowing of freer breathing in some ways, taking it all round, Clover's is *the best*

apparatus for the closed administration of ether ever devised, and the principle adopted in Hewitt's is, of course, the same. It is essential to procure one from a reliable high-class instrument-maker and not a cheap type, the bore of which is usually narrow and the instrument sometimes defective in other ways.

The actual fixing on of the face-piece by a screw attachment in Hewitt's marks an advance, and the face itself is a very good and durable one. Some face-pieces for Clover's inhaler are badly designed and calculated to allow of leakage.

The body of the inhaler consists of a spherical metal ether chamber, upon one hemisphere of which is fixed a water-jacket to render the temperature as constant as possible. The jacket takes the form of a cylindrical extension. The chamber is provided with an aperture for introducing the ether, to which is fitted a vulcanite stopper enclosing a glass bulb indicator.

When the bulb is in the dependent position, the ether, if any remain in the chamber, is seen to be there.

Water-jacket and chamber alike are pierced by a central tube, which has a slot cut in it about one-third of the distance from either end, giving access in this way to the ether contained. Just opposite these slots the tube (the metal of which

is continuous with that of the chamber) is of larger bore than elsewhere.

A separate metal tube distinct from the chamber is accurately fitted into this tube or outer sheath with slots which correspond to those above mentioned, but between them a metal diaphragm occludes the lumen of the tube. This inner tube is continuous on the one hand with the face-piece, and on the other with the rubber bag.

Fixed on the inner tube between the face-piece and the water-jacket is a stout wire indicator which points at figures marked on the surface of the water-jacket, indicating very roughly the strength of the vapour used. It really refers to the degree of coaptation between the slots in the inner and outer tube, and when they completely correspond stands at *F*, or full. At this point all the air inspired from the bag by the patient passes over the ether contained in the metal chamber, and is strongly impregnated with ether, so much so as to be practically irrespirable except by a semi-unconscious patient. At *O* the tubes do not coapt at all, but all the ether is shut in the metal container, none getting into the patient's lungs. It cannot get past the metal diaphragm, but uses the expansion before mentioned in the outer tube, which is a sort of by-pass; 1, 2, 3, express varying degrees of coaptation.

As a rule the Clover inhaler is made of metal in its entirety. A chamber has been put on the market by Maws, however, which is partly glass and partly metal. The ether is contained in a spherical glass chamber, on one side of which the metal water-jacket is fixed with plaster of Paris. This has the advantage of allowing the administrator to see what ether he has to come and go on at all times, and it is a very clean and pretty instrument. On the other hand, it is more fragile. One of us has had one in pretty regular use now for over ten years, and never had the glass chamber broken, and if it does break it is not expensive to replace Apart from any other advantage, it is very useful in getting students and others to understand the mechanism of the Clover inhaler, as they can see most of it.

HEWITT'S INHALER.—This differs from Clover's pattern in the following particulars:

1. The internal calibre is very much larger—indeed, about twice the size of the Clover.

2. The central tube rotates within the fixed ether reservoir, instead of the ether chamber rotating, as in the Clover inhaler.

3. The face-piece is screwed on—a distinct advance, especially with nervous and alcoholic patients who struggle.

4. The ether reservoir can be adjusted what-

ever the position of the patient, so that fresh ether can be added without suspending the administration by removing the face-piece from the patient. The inner tube is in two sections, which are made to revolve simultaneously by means of the handle, which is loop-shaped, with an arm fixed in each.

With this apparatus there is less tendency, especially when the administrator is inexperienced, of stertor, cyanosis, and laboured breathing. It has not, however, generally displaced the Clover, chiefly, probably, as it is rather more expensive.

The Administration of Ether by the Closed Method.

Where possible, it is usually desirable to start ether anæsthesia by rendering the patient unconscious with nitrous oxide (see Sequences), or by a small amount (3 to 5 c.c.) of ethyl chloride; but with plain ether anæsthesia is very easily and rapidly induced in a Clover's inhaler by any adequately trained anæsthetist without undue discomfort to the patient. The vapour is, of course, fairly pungent and the smell long remembered, and usually detested after the event; but it is for the administrator to see that the vapour strength is carefully graduated so as to cause as little coughing and holding of the breath as possible. This may

be easily accomplished with the skilful manipulation of a Clover, which compares very favourably with the Ormsby inhaler in this respect. Even if nitrous oxide precede ether given in an Ormsby, when the gas-bag is removed and the Ormsby applied the breathing at once becomes 'choky,' and there is a considerable degree of anoxæmia and cyanosis until the patient becomes deeply anæsthetized and air can be freely permitted.

All this can be avoided with Clover's inhaler. It is first charged with the necessary amount of ether—for dental work $\frac{1}{2}$ ounce usually being more than sufficient—the index set at *P*, and any ether vapour carefully blown out of the tube.

The face-piece is then carefully adapted to the patient's face. Care must be taken there is no leakage at the upper extremity over the bridge of the nose, where it is most liable to occur, except in the case of people with beards, when it is always difficult to prevent.

In strong-jawed muscular types, especially if there are no gaps in the front teeth already, it is best to start with a small mouth-prop, in order to allow of the mouth being readily opened with a gag.

To start, one or two breaths are caught in the bag, or the patient asked to blow into it, and then

the index is moved a small fraction from zero towards 1.

If the patient breathes away comfortably it is again advanced, and again, until 1 is reached. If the breath is held and the vapour seems too strong for the patient at any point, the index needle should be switched back $\frac{1}{2}$ inch or more and a few breaths allowed of the weaker vapour, and then another advance made. The principle is *reculer pour le mieux sauter*. After such a withdrawal very often a more rapid advance can be made, and the patient quickly becomes tolerant of stronger vapours, and anæsthetized.

Unless the vapour strength be increased only with discretion and caution, delay is bound to occur and very undesirable salivation.

Once anæsthesia is established and the pupil fairly dilated, ·3$\frac{1}{2}$ to 4$\frac{1}{2}$ millimetres a breath air to 3 or 4 of ether may be usually allowed on principle.

After-Effects of Ether.

Sickness is rather more common than after chloroform, but very transient. Some ether-impregnated mucus and blood may be rejected in a few bouts of retching, and then the patient quickly recovers. It is always best that blood should be vomited, as it keeps the patient dull and upset in his digestion if retained for long.

Care must be taken not to give ether to people with marked naso-pharyngeal catarrh or tendency to bronchitis. Ether bronchitis and pneumonia are rare, however, in healthy subjects.

Certain people get very excited after ether, alcoholics and hysterical women in particular, and some restraint in such cases may be needed for a while.

CHAPTER VI

CHLOROFORM

WHILE the field for chloroform in dental surgery is extremely limited, as the indications given below will show, it is well that its chemical characteristics and mode of action should be referred to briefly even in a volume of this character. The drug was actually discovered by Samuel Guthrie, of Sacketts Harbour, N.Y., and *not* by Simpson, in 1831. Dumas established the chemical formula in 1835, and twelve years later Simpson *applied it* to anæsthesia in surgical operations.

Chloroform is a heavy liquid with a specific gravity of 1·495 at 62° F., devoid of colour and transparent, and neutral in reaction. It has an agreeable sweet odour, quite unirritating.

In the writer's own fairly extensive experience trouble during anæsthesia is very rarely indeed due to impure chloroform. The trouble lies with the method of administration of the drug or a difficult subject for it in the patient. Time and again has one of the authors used chloroform returned to

the makers as 'impure and dangerous,' and on no occasion has any difficulty arisen with it.

The method of the administration is simple in the extreme. On the whole, the Schimmelbusch mask is the most convenient means of stretching the lint which is the vehicle for the chloroform prior to its vaporizing. The patient should be carefully prepared—more so than with any other anæsthetic, and should not be moved from one room to another after the anæsthesia is established.

Two layers of lint or domett are stretched on the Schimmelbusch, and a drop-bottle of simple character used; one is easily improvised with a 3-ounce flat bottle and a perfume stopper.

A little vaseline should be placed, as a precautionary measure, on the most prominent part of the nose and chin, and perhaps on the cheeks of the person to be anæsthetized.

The dropping of chloroform (which should really not occur when it is properly administered) will leave a mark of a burn for some days.

The small metal holder or handle of the mask should be held in the administrator's left hand between thumb and forefinger, and a space of about $\frac{1}{2}$ inch intervenes between the bottom of the framework and the face. This secures a free supply of air, and permits of the escape of the

patient's breath with chloroform and CO_2 therein contained.

In commencing, the mask is applied for one or two breaths; and no chloroform should be put on it, in order to establish the patient's confidence, so to speak. Two or three drops of chloroform may now be put on the centre of the lint just where the supports of the mask cross in the centre.

Begin with 1 drop every inspiration, and then increase fairly quickly to 3 or 4. It is impossible to lay down any definite rule to apply to every patient. Each must be judged on his or her own merits, and an alcoholic, heavily built man may call for drachms, while a pale asthenic woman may go under on a minimum of drops.

While those not thoroughly accustomed to the drug must walk warily, there must be no undue dalliance over the early stages. It is in the early second stage of struggling that dangerous syncope sometimes takes place. Care must be taken, however, to avoid such an increase of vapour that the patient holds his breath from its pungency. Delayed induction at the same time may result in holding of the breath, with swallowing and vomiting. Thus the administrator must take the *via media*, and watch warily all the time. Let the pulse not worry him. The important thing is to register each respiration carefully on his tym-

panum, paying particular attention to its rhythm and keeping an eye on the colour generally and the pupil, to watch for the onset of flaccidity in the muscles.

The pupil dilates at first from the stimulation of the sympathetic nervous system. As consciousness is lost and the breathing deepens, the pupil gradually diminishes in size from stimulation of the third or oculo-motor nerve; it contracts down to about 2·5 millimetres diameter, but will dilate again if the chloroform is unduly pushed, and a *dilated fixed pupil is a danger signal.*

The administrator's *objectif* should be to establish a regular or automatic respiration, a more or less fixed and contracted pupil, complete muscular relaxation, and abolition of the corneal reflex. This last is always a sign to which students and inexperienced administrators attach undue value, and damage is apt to occur to the patient's sensitive eye surface from the constant and callous probing of it by the finger-tip.

Chloroform anæsthesia is rather arbitrarily divided into three stages, with a fourth which may be regarded as the danger zone. They are really not sharply defined one from the other.

In the first stage the patient rather resents the application of the vapour, and turns his face away, possibly swallowing and coughing slightly. He

has a hammering or throbbing sensation in his head, and is acutely sensitive to all noises, any conversation being most undesirable.

No operative procedure should be attempted at this stage, which rapidly passes into the second.

In this the patient has lost consciousness, talks rapidly, shouts or swears. Struggling occurs, exaggerated in the alcoholic, and a source of danger and anxiety always. The patient's movements are restrained, and he finally loses his breath, taking deep, gasping inspirations, which may dangerously load his blood up with chloroform if the vapour be concentrated.

Apart from struggling, there is danger of sickness at this stage, if there be undue delay in getting the patient 'under' or into the third stage.

The symptoms of this are almost unmistakable. There is regular automatic breathing, loss of conjunctival reflex, a fixed contracted pupil, and complete muscular relaxation.

As regards the pupil, if it is very small, under 2 millimetres, the risk of the patient having merely fallen asleep when half anæsthetized has to be borne in mind, and some sharp, painful stimulus, such as a prick or rubbing roughly of the external respiratory nerve, be desirable.

The Pupil in Anæsthesia.

Three changes require explanation—dilatation, contraction, and reaction to light.

The figure below gives a clear idea of the mechanism we have to rely on. First there is the sympathetic nervous system supplying the long ciliary nerves to the dilators of the pupil, and the central nervous system supplying the short

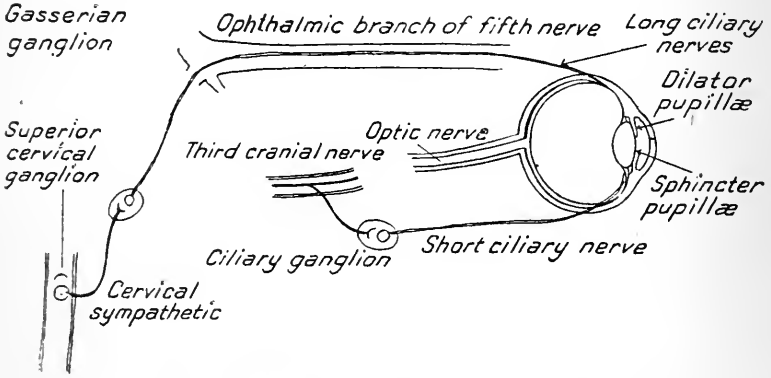

Fig. 13.—Diagrammatic representation of nervous mechanism of pupil.

ciliary nerves to the sphincter pupillæ. The mechanism is put in motion by both stimulation and by paralysis.

Stimulation.—Dilatation occurs when the sympathetic nervous system is stimulated. Contraction occurs when the central nervous system is stimulated by light—the afferent impulses travel-

ling through the retinal and optic nerve, and the efferent by the cranial nerve and short ciliary.

Paralysis.—When paralysis of the sympathetic system has taken place, the pupil contracts by virtue of the tone of the bloodvessels of the sphincters, aided by the engorgement of the ciliary bloodvessels. When the central system is paralyzed, dilatation takes place through the elasticity of the pupil and the emptying of the ciliary bloodvessels, which permit the lens to bulge forwards. It is very important to understand thoroughly the *modus operandi* as explained above.

Applying this clinically, we find during induction, the patient often being excited and nervous, the sympathetic nervous system is stimulated and the pupils usually dilated, depending on the degree of the excitement. As relaxation comes on the sympathetic becomes paralyzed and the pupil contracts, but the light reflex remains.

During the course of an anæsthesia the sympathetic system becomes paralyzed, and if deeply the pupil will contract to 2 to $2\frac{1}{2}$ millimetres and not react to sympathetic stimuli. The important point to observe and decide upon is whether subsequent dilatation is due to returning consciousness or to deepening anæsthesia and paralytic dilatation due to paralysis of the central nervous system. If the anæsthetic be withdrawn

and the pupil contract, the dilatation is known to have been the dilatation of paralysis.

When the pupil is contracted, with an active light reflex, the condition of the patient can be regarded as safe, but the anæsthesia is not profound.

Blood-Pressure in Anæsthesia.

This is a subject which has of late attracted much attention, and good work has been done by Guy Goodall and Reid conjointly.* Modern apparatus, etc., have made such researches in clinical work much more easy.

While the dental surgeon cannot be expected to use a sphygmomanometer in daily routine, some remarks on the general aspects of the question seemed called for in a book of this character.

Now, blood-pressure may be lowered in various ways: (1) By depression of the heart's action by vagus inhibition direct or reflex (as in tooth extraction or any painful stimulus under light anæsthesia, especially chloroform anæsthesia), or by weakening of the heart muscle; (2) by dilatation of the vessel wall or vaso-motor paralysis.

Blood-pressure may be raised similarly by—

* *Edinburgh Medical Journal*, August, 1911.

(1) Stimulation of the heart by excitement—*e.g.*, of the coming operation, or by stimulation of the heart by the drug used—*e.g.*, ether; (2) by stimulation of the vaso-motor centres—*e.g.*, by the action of the drug or by CO_2 in asphyxia.

Clinical study and experiment alike show that different anæsthetics act on the blood-pressure in different ways, and it has to be borne in mind that the depressing effect of any anæsthetic on the blood-pressure determines very largely the relative danger of that anæsthetic and its tendency to produce shock.

Nitrous Oxide.

When given alone so as to produce rapid anæsthesia, this drug usually causes a brief elevation of blood-pressure, due to partial asphyxia or anoxæmia induced. It is not so marked when rebreathing is allowed, and is almost completely eliminated when a gallon of oxygen is concomitantly inhaled. This is a point worthy of note when dealing with apoplectic types of patients.

Nitrous Oxide and Ether.

A gradual elevation of blood-pressure is effected, just as with plain ether. The onset of shock where the patient is enfeebled is delayed or averted.

Nitrous oxide and oxygen causes a primary rise in blood-pressure, which immediately falls to normal as the stage of analgesia is reached.

By the judicious use of oxygen any tendency to elevation may be controlled almost indefinitely. If the oxygen be suddenly increased or the nitrous oxide withdrawn, a sudden marked elevation may occur which persists for a quarter of an hour or more.

Ethyl Chloride and Somnoform.

Both these drugs have been administered more carefully, as already pointed out (p. 92). Apart from the tendency to spasm and asphyxia which we have remarked on, they have the effect of powerful inhibition of the heart and bloodvessel tone, causing a progressive fall of blood-pressure.

The pulse usually quickens, and a very quick pulse may accompany a dangerous hypotension. Oxygen used in combination with ethyl chloride tends to lessen this effect.

Ether.

Ether does not cause any great alteration in blood-pressure, though there may be a primary rise or fall; usually there is a pretty constant level maintained. The heart beats more rapidly and more forcibly with some dilatation of the smaller vessels, the latter effect probably counter-

acting the former. If shock develop under ether there is considerable concomitant cardiac depression, and the recovery therefrom is slow.*

Chloroform.

A reduction in blood-pressure of from 10 to 20 millimetres Hg is usual with the administration of chloroform, the degree largely depending on the concentration of the drug. The fall may occur suddenly and to a dangerous degree even after the administration of a few cubic centimetres of chloroform.

Its effect on blood-pressure goes to confirm the view that this drug is dangerous at all stages of its administration, the greatest danger being in the early stages of anæsthesia and during light anæsthesia, and this danger is enhanced if struggling occur.

In what class of case is it permissible, and even advantageous, to administer chloroform for dental operations?

The routine use of chloroform in an extensive dental extraction is condemned in unqualified language in these pages, but let the reader make no mistake—neither of the authors is an ether faddist, nor would they hesitate for a moment to

* H. P. Fairlie, *Lancet*, February 28, 1914.

use chloroform in a dental extraction in certain circumstances. It may be necessary at times for doctors in remote districts to do the same because at the moment ether may be unavailable, or, if the drug is available, there may be no inhaler. But apart from this exceptional circumstance, it may be necessary where there are several difficult teeth or stumps to remove from a patient who has some chronic heart or pleural trouble or abdominal growth of extensive proportions, attended with dyspnœa.

Further, when the patient has been or is insane, or is subject to epilepsy, on the whole it is wiser to give chloroform, as less liable to produce cerebral vascularity and excitement than ether or even nitrous oxide.

Insanity occurs from time to time as a sequela of all anæsthetics, but probably fewer cases are found to occur after chloroform than ether or nitrous oxide. One of us has seen two cases of temporary mental aberration after the last-named anæsthetic, and two of maniacal excitement after gas and ether lasting for two hours.

These cases, however, are exceedingly rare, and such complications need only be anticipated in highly neurotic individuals.

If *it seems advisable, taking the circumstances into account, to use chloroform,* the chief points to

which attention should be paid in the administration are:

1. Seeing that there is a liability when chloroform is used in dental operations for undetected embarrassment of breathing to arise, it is of paramount importance that the administrator should make absolutely certain, from the commencement of the administration till consciousness is restored, that air is entering and leaving the chest. Mechanical obstruction within the air-tract, from the numerous causes which are fully discussed, is very prone to arise, and unless the administrator actually hears or feels throughout the administration that breathing is proceeding, he will be very liable to be misled.

2. The administration should be conducted with the patient in the dorsal posture, the head and shoulders being so adjusted by pillows that the head is neither flexed nor extended.

3. Owing to the fact that breathing is liable to become interfered with by either extending or flexing the head upon the trunk (a point to which the author wishes to direct special attention), an attempt should be made to keep the head as far as possible in the longitudinal axis of the body. Should it become necessary to throw the head well back, this should be done when the patient is properly under the anæsthetic, care being taken

whilst this extension is present that no blood or extracted teeth gravitate towards the now insensitive and open larynx.

4. Care should be taken during the operations upon the lower jaw, or when employing a mouth gag or prop, that the depression of the lower jaw does not interfere with breathing by causing the tongue to meet the pharyngeal wall.

5. Intercurrent asphyxia from the causes which are given is far more likely to arise during light than during deep anæsthesia, so that the administrator should be on the alert for it just as the patient is entering and leaving the latter state.

6. The patient should be placed deeply under chloroform before any operation is begun. Should any signs of recovery manifest themselves before the operation is completed, care should be taken in reapplying the chloroform. The patient's head should be turned to one side, a free air-way maintained by means of a gag, and from this point onwards only a moderately deep anæsthesia should be kept up.

7. Patients with naso-pharyngeal adenoid growths, enlarged tonsils, or nasal polypi, should be anæsthetized with special care, owing to the greater tendency to become asphyxiated which such patients naturally display.

8. At the conclusion of the operation the patient

should at once be turned upon his side, a Mason's gag being placed between his jaws till consciousness is restored. The side posture allows all the blood to drain from mouth and fauces, the tongue to gravitate towards the cheek, and by reason of the free respiration established the $CHCl_3$ escapes from the circulation.

The rapid development of conservative dentistry during recent years has struck a salutary blow at the reckless and ruthless removal of decayed and defective teeth; but nevertheless extensive extractions are carried out in thousands of cases annually, and familiarity with such a lethal anæsthetic as chloroform has given both practitioner and dental surgeon a sort of contempt for its dangers which there is no possible ground to justify. Very much to the contrary. We propose to enter into the question of chloroform risks very fully.

In August, 1895, the late Sir Frederick Hewitt read a most interesting paper before the British Dental Association meeting at Edinburgh on this special matter. He stated that he found in Scotland, where chloroform was used as a routine anæsthetic in dental work, that the ratio between the number of dental anæsthetic fatalities occurring between 1880 and 1894 inclusive and the population was about four times higher than the ratio for England and Wales.

In Scotland, however, no coroner's inquests are held, and cases ending fatally are less likely to be made known than in England, and the proportion of deaths is in all probability higher than Dr. Hewitt estimates.

TABLE I.—DEATHS IN CONNECTION WITH GENERAL ANÆSTHETICS ADMINISTERED FOR DENTAL OPERATIONS IN GREAT BRITAIN, 1880-1894.

ANÆSTHETIC USED.	SCOTLAND. Approximate Population, 4 Millions.	ENGLAND AND WALES. Approximate Population, 23¾ Millions.	LONDON. Approximate Population, 4¼ Millions.
1. $CHCl_3$	12	15	0
2. $CHCl_3$ and morphia ..	1	0	0
3. $CHCl_3$, ether, mixed ..	0	1	0
4. Methylene (really dilute $CHCl_3$)	0	2	0
5. Ether	0	1	0
6. Nitrous oxide	1	2	2
	14	21	2

Of the twenty-seven deaths from $CHCl_3$, nineteen were reported with sufficient fulness to admit of analysis and comparisons being made of them.

Sex.—Fourteen were females and five males. Generally speaking, women take chloroform and all anæsthetics better than men.

C

CO BE MADE.)

ena.	*Post-mortem.*
Lerved and no pulse could be felt. then ceased.	?
Fe suddenly left face and patient	All organs healthy.
Eath-like, bluish pallor swept over	None.
Fothing were both found to have	?
came weak, a slight epileptiform although respiratory movements	Flabby, rather dilated heart. Valves healthy. Kidneys slightly enlarged and congested. Other organs healthy.
l turned pale. Upon examination, felt, but breathing continued for fter a few respirations the colour respiration, but without success.	Except a little kidney disease, all organs healthy.
ei fell back.	?
h apparently from syncope.	Both lungs in a damaged condition. Heart contracted and empty.
ist cried out and attempted to re- olour became bluish-white, the breathing weak and shallow.	?

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TABLE II.—BEING GROUP I. OF THE TWENTY-SEVEN CHLOROFORM FATALITIES.

(GROUP I. INCLUDES THOSE FATALITIES, NINETEEN IN NUMBER, WHICH HAVE BEEN REPORTED WITH SUFFICIENT FULNESS TO ENABLE A CLASSIFICATION AND ANALYSIS OF THEM TO BE MADE.)

Classes.	*No.*	*Sex.*	*Age.*	*General Condition.*	*Preparation.*	*Posture.*	*Method and Quantity.*	*Nature of Operation.*	*Relation of Dangerous Symptoms to Operation.*	*Phenomena during Administration and Operation.*	*Fatal Phenomena.*	*Post-mortem.*
CLASS 1.—Cases in which the dangerous phenomena came on during a deep anæsthesia.	1	F.	21	Of a nervous temperament.	Examined, and chloroform found admissible.	?	Folded napkin.	Large number of roots to be removed. Six or eight extracted.	During.	Longer time than usual to produce anæsthesia. When deeply anæsthetized six or eight lower roots removed.	After six or eight roots removed, paller observed and no pulse could be felt. No heart action detectable. Breathing then ceased.	?
	2	F.	About 35	Thin and spare; accustomed to faint.	Clothing loose. No breakfast. Operation 11.30 a.m.	Recumbent in a chair-bed with a cushion beneath shoulders; otherwise quite flat.	On napkin.	For the removal of several loose teeth. Operation nearly finished.	Do.	Placed thoroughly under the influence of chloroform. About one-third total number of teeth removed. More chloroform given. More teeth removed. Everything apparently going well. More chloroform given. Very little hæmorrhage observed during operation.	After last dose of chloroform given, colour suddenly left face and patient collapsed.	All organs healthy.
	3	F.	About 21	'Not over-robust looking.'	?	?	?	Eighteen upper and lower roots to be removed. Three extracted.	Do.	Difficult to obtain anæsthesia. Operation begun when patient thoroughly under.	Whilst fourth root was being removed a death-like, bluish paller swept over face	None.
CLASS 2.—Cases in which the dangerous phenomena came on during a light anæsthesia.	4	F.	24	Very nervous and excitable.	'Every care taken.' Corsets loosened. Heart examined.	Reclining in a low easy-chair with head thrown well backwards by means of pillow under back.	40 or 50 min. on lint.	For removal of several teeth. Operation not begun.	Before.	Inhaled about 'three times.' Slipped forwards in chair. Head dropped forwards.	When she slipped forwards, pulse and breathing were both found to have stopped.	?
	5	F.	37	Healthy looking, stout, rather nervous. Had had severe neuralgia for two years. Heart sounds clear. Pulse good.	Corsets and clothes thoroughly loosened. Patient 'examined.'	Semi-recumbent in lowered dental chair.	℥ss. used on Skinner's inhaler.	? Proposed operation. Operation not begun.	Do.	Respirations free and easy.	After 30 drops had been given the pulse became weak, a slight epileptiform seizure took place, and the heart failed, although respiratory movements continued.	Flabby, rather dilated heart. Valves healthy. Kidneys slightly enlarged and congested. Other organs healthy.
	6	F.	37	Perfectly healthy.	Cautioned not to take food.	?	About ℥ij. used.	? Proposed operation. Operation not begun.	Do.	Took it very well. Perhaps a little more struggling than usual.	Nearly ready for operation when she suddenly turned pale. Upon examination, no heart sounds audible, and no pulse to be felt, but breathing continued for some time. Another account states that after a few respirations the colour changed, and attempts were made to restore respiration, but without success.	Except a little kidney disease, all organs healthy.
	7	F.	35	Extremely nervous.	Dress loose. No food recently.	Sitting.	A little over ℥ij. on Skinner's inhaler.	Several teeth to be removed. ? How many extracted.	During.	Excited during operation, crying and laying hold of operator's hand. Jumped up. Struggled for two minutes. Then fell back. No reapplication of chloroform.	Was dead in less than five minutes after she fell back.	?
	8	F.	Young	?	?	?	?	Three teeth to be removed. Two extracted.	Do.	Signs of returning consciousness, with raising of hands during extraction of third tooth. Only partially anæsthetized throughout.	Expired immediately after lifting of hands, apparently from syncope	Both lungs in a damaged condition. Heart contracted and empty.
	9	M.	11	Fair; convalescent from measles.	Solid food four hours before.	Lying on couch. Head and shoulders slightly elevated.	Folded napkin.	Six molars to be extracted. Five or six removed.	Do.	Required a good deal of chloroform. Cried out when operation begun. More chloroform given. Breathing normal. Pulse moderate.	Whilst last tooth was being extracted patient cried out and attempted to resist. Just before operation completed colour became bluish-white, the patient became quiet and flaccid, and the breathing weak and shallow.	?

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mena.	*Post-mortem.*
, and quickly died.	?
ed, respiration and action of heart rtificial respiration attempted, but	?
d become sensitive, pupils suddenly and face blanched. Although the ng continued for about two minutes.	None.
peared, closure of eyes and spasm of reathing, were observed. Artificial hen it was suspended another con- g could not again be started.	Evidence of old pleurisy. Kidneys, lungs, and liver congested. No cardiac disease.
ver, pallor suddenly occurred, and	None.
t was observed to be cyanosed and for a few minutes she gave a few	Heart pale and flabby. Fatty infiltration of tissues of heart and body.
ing suddenly ceased, pupils dilated, se was then beating feebly, but it	?
n patient appeared to faint. A few he heart's action had failed.	Heart and lungs healthy.
bserved. Breathing continued for be felt.	?
	None.

TABLE II.—BEING GROUP I. OF THE TWENTY-SEVEN CHLOROFORM FATALITIES—*continued.*

Classes.	No.	Sex.	Age	General Condition.	Preparation.	Posture.	Method and Quantity.	Nature of Operation.	Relation of Dangerous Symptoms to Operation	Phenomena during Administration and Operation.	Fatal Phenomena.	Post-mortem.
Class 2.—*continued.*	10	F.	16 to 17	Rather anæmic.	?	In dental chair placed at about angle of 45 degrees.	Junker's inhaler.	For several teeth. Seven or eight removed.	Do.	Took it well. After seven or eight teeth out, showed signs of recovery. More chloroform given. Struggled.	After struggling she became opisthotonic, and quickly died.	?
	11	M.	36	Good; able to undergo great fatigue.	'Examined,' and chloroform found to be admissible.	?	?	? Proposed operation. One tooth and three roots removed	During or after.	Some excitement. Never entirely under influence of chloroform. One tooth and three roots removed. Patient quiet during operation. Was under for five to seven minutes.	After one tooth and three roots removed, respiration and action of heart suddenly ceased. Face blanched. Artificial respiration attempted, but could not be induced.	?
	12	F.	25	?	?	Seated in an easy-chair, some reclining.	3ij. on an open inhaler.	One tooth to be removed. Operation completed.	After.	Apparently not abnormal.	After operation over and conjunctiva had become sensitive, pupils suddenly dilated, pulse became imperceptible, and face blanched. Although the heart could not be felt beating, breathing continued for about two minutes.	None.
	13	F.	21	Strong, full-blooded. No history of convulsions or fainting attacks.	No food for several hours.	'Was laid on the sofa.'	?	Nine teeth to be removed. Operation completed.	Do.	About 3j. of chloroform required to produce unconsciousness. After nine teeth had been extracted from upper jaw patient showed signs of coming round.	After signs of returning consciousness appeared, closure of eyes and spasm of hands, arms, and legs, with arrested breathing, were observed. Artificial respiration restored breathing, but when it was suspended another convulsive seizure occurred, and breathing could not again be started.	Evidence of old pleurisy. Kidneys, lungs, and liver congested. No cardiac disease.
	14	M.	8 to 10	A fresh-coloured lad. Has bronchial catarrh in winter.	Clothing loose and chest exposed.	On table. Pillow under head.	Napkin.	Two lower, four upper teeth to be removed. Operation completed.	Do.	Lower teeth first removed. During extraction of upper, patient cried out, struggled, and turned over on his side. Everything apparently satisfactory.	Three to four minutes after operation over, pallor suddenly occurred, and patient died.	None.
Class 3.—Cases in which it is difficult to say whether death was due to chloroform given during a deep or a light anæsthesia.	15	♭	17	?	?	?	Skinner's inhaler.	Nine teeth to be removed. Eight extracted.	During.	Took it well. Well under in five minutes. During extraction of eighth tooth showed signs of recovery. A few drops more chloroform given.	During extraction of ninth tooth patient was observed to be cyanosed and pulseless. After artificial respiration for a few minutes she gave a few gasps.	Heart pale and flabby. Fatty infiltration of tissues of heart and body.
	16	F.	21	Fairly nourished. Rather anæmic. Weak heart action.	?	Dorsal.	On lint. A little over 3vj used.	? Proposed operation. About thirteen teeth removed.	During or after.	Took it well. Required rather more than usual. After ten teeth had been removed showed signs of coming round. More chloroform given. Breathing good and regular up to this point. No stertor. Three more teeth extracted.	After removal of last three teeth breathing suddenly ceased, pupils dilated, and lips became slightly livid. Pulse was then beating feebly, but it stopped within a minute.	?
	17	M.	33	Active, but not strong.	?	?	Administered 'in the usual way.'	One tooth and one stump to be extracted. Operation completed.	After	?	Operation had just been completed when patient appeared to faint. A few respirations occurred after this, but the heart's action had failed.	Heart and lungs healthy.
	18	M.	11	?	Prepared by diet, etc., for operation at 11 a.m. Alveolar abscess.	Ordinary easy-chair.	Towel.	Roots of one tooth and then two whole teeth removed. Operation completed.	Do.	After roots removed, struggling occurred. More chloroform given. Operation successfully completed.	When operation over, sudden pallor observed. Breathing continued for about one minute, but no pulse could be felt.	?
	19	F.	?	A barmaid.	None. She was wearing a tightly-fitting new dress.	In dentist's chair.	?	?	?	?	?	None.

Age.—Most of the fatalities occurred in young patients, the range being from eight to thirty-nine years.

General Condition.—There was no case in which the condition of the patient precluded the use of an anæsthetic or rendered anæsthesia perilous. At the present day those competent to judge consider that the presence of cardiac disease or 'weak' heart in no way contra-indicates the employment of an anæsthetic.

Preparation.—In a few of the cases the patient was in no way suitably prepared, one being attired in a tightly-fitting dress.

Summary of Objections to Chloroform in Dental Surgery.

1. The known higher death-rate, which, taking into account that a dental extraction is largely an operation of *choice* and not of absolute necessity, should put chloroform out of court.

2. The tendency to syncope during chloroform anæsthesia after struggling, from the erect posture or from vagus inhibition.

3. The short duration of true anæsthesia from chloroform and consequent need for repeated administration—the danger of vagus inhibition and 'shock' being greatest during light anæsthesia.

If the patient is bleeding freely, the anæsthetist naturally shrinks from deepening the anæsthesia, and the patient simply lies between Scylla and Charybdis.

4. The necessity for maintaining the recumbent position during chloroform anæsthesia, a position most difficult for extraction.

5. The often prolonged after-sickness and digestive disturbances caused by inhaling chloroform.

6. The need for thorough and careful preparation of the patient, which often may be done without in ether cases.

We will now endeavour to explain at length why chloroform is essentially an unsuitable anæsthetic for dental surgery, and wherein the danger in using it in this department lies.

In the first place, it is a very great advantage indeed for the operator to have the patient who is to undergo the extractions seated in a dental chair in a good, strong light, particularly if there is likely to be any difficulty with roots, etc. Now, it is well known that giving chloroform to a patient in the sitting posture is an extremely hazardous proceeding, frequently ending in the death of the patient from syncope, and accidents have occurred so often that the practice has been quite abandoned. The explanation of the marked tendency to syncope lies in the fact that chloroform, more

than any known agent, possesses the faculty of destroying the compensatory effort of nature for the effect of gravity as regards the circulation. Accordingly, when a patient is fully under its influence, the arteries have little more contractibility in them than gas-pipes for the time being, and the blood tends to gravitate downwards and to points of least resistance—*e.g.*, the large abdominal vessels, or the ' abdominal pool ' of Leonard Hill. The brain and centres of the respiration and circulation in the medulla become anæmic and unable to carry on their functions, and the patient collapses and dies of syncope.

Out of 716 deaths under chloroform recorded in the *Lancet* clinical report, fifty-six occurred during the extraction of teeth, and in the bulk of these the patient was in the sitting position.

The recumbent position, then, is an absolute essential to the safety of the patient, but from the point of view of the operator most unsuitable. Further, in this position there is another element of risk to be considered—viz., teeth or roots slipping from the forceps and passing into the respiratory passages—an accident more likely than when the patient is sitting up.

In investigating the relative mortality of ether and chloroform, we have evidence obtained from the Physiological Laboratory, due to the re-

searches of Coates, Leonard Hill, McWilliam, and others, and also abundant clinical evidence, to weigh down the balance in favour of ether. The conclusion of the late Professor Coates, as far as laboratory results are concerned, was that 'he was firmly convinced from multiplied experiments that ether exercises much less of a paralyzing action on the intrinsic ganglia of the heart than chloroform does,' and 'that, as far as laboratory experiments were concerned, ether came out distinctly better than chloroform.'

It is found that death during the administration of chloroform is due, in the large majority of cases, to cardiac syncope, which may arise from:

1. Reflex stimulation of the vagus,* causing inhibition of the cardiac pulsations; this occurs in light anæsthesia, due to insufficient chloroform.

2. Depressant action of the chloroform on the

* Although in the experiments carried out by the Hyderabad Commission on dogs and monkeys reflex inhibition of the vagus was not found to occur, in man it must be accepted as a fact. Dudley Buxton states that his own experience enables him to speak dogmatically on this point, for he has again and again seen the circulation and respiration both profoundly interfered with by reflexes when a patient has been under the influence of chloroform. In dental operations, where the shock occasioned by the laceration of the branches of the fifth or trifacial nerve is out of all proportion to the severity of the undertaking, there is an especial danger of primary cardiac failure through reflex cardiac inhibition.

medullary centre of the heart, the vaso-motor centre, the intrinsic ganglia, and on the myocardium itself.

Death in this manner is due to overdose—of course, overdose is purely a relative term—in regard to which the personal equation must bulk very largely.

While death is most commonly due to heart failure of circulation, it may be due to cessation of respiration occurring in three separate ways:

1. Direct obstruction from—

   (*a*) Laryngeal stertor, due to spasm and approximation of aryepiglottidean folds.

   (*b*) Falling back of the tongue.

2. Direct retardation and arrest of the pulmonary circulation—first in the capillaries and later in the larger vessels—due to the direct local action of chloroform.

3. Interference with the respiratory centre in the medulla and the subordinate centres in the spinal cord.

With reference to the last, we must bear in mind that in chloroform we have a drug which acts by temporarily paralyzing the nerve-centres.

The higher centres it is our object and desire to paralyze, but we have only to go a step further to

produce a similar effect on those governing the vital processes.

We thus observe that chloroform kills in two distinct ways by its action: (1) on the circulation, (2) on the respiration.

Probably these actions are frequently combined and occur simultaneously. There has been much useless controversy on the subject.

Examining the manner by which a fatal issue is arrived at with ether, we find the possibilities, and consequently the likelihood, of a fatal tissue much less numerous.

Death may arise from cessation of respiration due to:

1. Direct obstruction from laryngeal spasm, falling back of tongue, etc.

2. Spasmodic contraction of respiratory muscles, arising, as a general rule, from overdose —a very unlikely event if reasonable care be exercised, the patient watched, and cyanosis avoided.

The *modus operandi*, as in the case of chloroform, is the paralysis of the respiratory centres, due to overloading of the blood with ether; and there is, as a general rule, ample time for the avoidance of a fatal issue by the use of artificial respiration.

With chloroform, however, when the blood is so saturated as to cause paralysis of the respira-

tory centres, the circulatory centres will be very seriously interfered with, if not already paralyzed, and satisfactory result from the application of restorative measures is less likely on this account.

Syncope during the administration of ether is almost unknown. The drug is itself a cardiac stimulant, and if heart failure does occur, it is due to some constitutional dyscrasia or to lowered vitality.

We would naturally expect from the respective actions of chloroform and ether, as briefly stated above, that fatalities would be more frequent in the case of chloroform, and our expectations are borne out by clinical results. Many statisticians have laboured at the subject during the past half-century, but it is not necessary to enter into their special findings in any great detail in this work.

Roughly, the mortality under chloroform is 1 in 1,000, and that of ether 1 in 10,000. The records of a very large general hospital in London, where the anæsthetics are administered by highly trained anæsthetists, over a period of twenty-five years give the following results:

Chloroform given 37,914 times, 29 deaths = 1 in 1,331.
Ether „ 32,674 „ 3 „ = 1 in 11,262.

Thus it is demonstrated that in a hospital where the anæsthetics are given with a very high degree

of skill fatalities under chloroform are just nine times as numerous as those of ether.

The death-rate under nitrous oxide is low in the extreme, being about 1 in 10,000; ethyl chloride, 1 in 15,000.

Thus it is apparent that a medical practitioner who ignores these facts and persists in giving chloroform for dental operative procedures, because he is too old or too lazy to adopt more modern methods, is not only deserving of the severe censure of his fellows and his patients, but really merits the attention of the General Medical Council: we had almost said the Public Prosecutor. The public are getting to learn the facts of the case, and to know how to protect themselves in many cases. The less well informed may become victims, but those who victimize them deserve the very strongest condemnation.

Death *from* an anæsthetic is a very different thing from death *under* an anæsthetic. In the first case the drug is the principal cause; in the second the actual cause of death may be something widely different.

No anæsthetic has been yet discovered which is entirely free from danger under any circumstances. A person in ordinary health requiring a minor operation, such as the extraction of several teeth, takes a few whiffs of chloroform, and with

little or no warning turns pale, his pulse and breathing stop, and he dies. A post-mortem examination fails to show any adequate physical or pathological cause for death, and the only conclusion to be arrived at is that the substance used to induce anæsthesia was the actual cause.

Pure ether, skilfully administered, *never* kills healthy people. Chloroform occasionally does, and in the manner and under the circumstances we have above described. About 40 per cent. of the fatalities which occur under chloroform take place in reasonably healthy persons undergoing operations of a minor character without any element of danger. These deaths commonly occur in the early stages of anæsthesia before the patient is really ' under,' and very often in subjects who have previously taken the drug quite well. No blame can be attached, in the vast majority of instances, to the quality of the chloroform, very seldom to the actual method of administration. These accidents have occurred in the hands of men like Simpson, Syme, Erichsen, Hunter Maguire, and many highly trained specialists. Surely, then, an agent not safe in the hands of men like these cannot *and certainly should not be relied on by the average medical practitioner for the production of anæsthesia for ordinary routine dental extractions*, as in some parts of Scotland.

It is the toxic nature of chloroform, and the capricious way in which it acts on different people, which constitute its chief danger. Ether is *never* uncertain in its action. It has its disadvantages and contra-indications, but there is always plenty of warning of any difficulty, and ordinary restorative measures taken in time amost always overcome the trouble.

The onset of dangerous symptoms in chloroform anæsthesia is terribly sudden, and in the majority of cases of true chloroform syncope occurring during the early stages all efforts to restore animation are entirely useless.

Repeated controversies have been carried on in the medical journals and elsewhere as to whether the heart or the breathing stopped first, but have resulted in little profit to anyone. It makes no difference to the patient or his friends which stops first; the result in any case is too often disastrous.

In spite of the most painstaking investigation of the whole question of chloroform anæsthesia by individuals and commissions, the practical fact stands out with terrible distinctness that the death-rate from chloroform has not decreased, but increased, and markedly so.

CHAPTER VII

SEQUENCES AND COMBINATIONS

Nitrous Oxide and Oxygen.

It has been quite a common thing for anæsthetists and dental surgeons to notice with some amusement the alarm engendered in patients' friends—if present at a nitrous oxide case—and even in the family practitioner, by the somewhat horrific aspect assumed by the person anæsthetized, with the deep cyanosis and facial contortion.

We have personally known the doctor to be on the point of intervening to protect his patient and cry "Hold! enough!" fearful of a cerebral hæmorrhage or complete asphyxia.

Possibly this drawback to nitrous oxide pure and simple led to attempts to induce a more tranquil and pretty anæsthesia by other means, and the first step towards an oxygen and N_2O combination was the allowance of an admixture of air given in the proportion of 25 per cent., or one breath of air in every five inspirations. This is attributed both to the late Mr. George Rowell and Mr. Carter Braine.

Nitrous oxide and oxygen anæsthesia has acquired during the war an importance and a degree of general recognition which was anticipated only by those few who in this country and the U.S.A. had been working for some years to perfect its administration. Briefly put, its advantages over other anæsthetics are as follows:

(*a*) It protects the patient from surgical shock much more effectively than does any other anæsthetic.

(*b*) It is non-toxic. The patient recovers in a few minutes from the longest inhalation, with his tissues and his metabolic processes unaffected by the drug. He can take full nourishment from the very inception of his convalescence. All this is in strong contrast with ether and chloroform, after either of which he has to pass through a period of depression and nausea, etc. On the other side of the account, we must admit that the method is costly and the apparatus cumbersome and, in its most highly developed forms, almost immobile. These factors have not in this war, however, prevented a wide use of the method, which has been of untold help to great numbers of our men, particularly those most severely wounded and most heavily infected with sepsis. To say that all this does not concern the dental surgeon in his

professional capacity is to take a very partial view of the case. Judgments and valuations formed at the Front come home with the men who formed them, and in the near future we may expect to see a genuine demand, both from surgeons and patients, for a more extended use of gas-oxygen. In the response to this demand, the progressive dental surgeon will naturally wish to take his due part.

The inquirer into this branch of anæsthesia is met at the very threshold by the difficulty in selecting an apparatus good in itself, and suitable for his requirements; and is apt to lose himself in a mass of makers' catalogues and pamphlets specially written to extol the virtues of one particular machine. Perusal of this literature without a good preliminary grasp of root principles tends to involve the whole subject in confusion and to make it appear much more complicated than it really is.

The names of the different gas-oxygen apparatuses are legion, their appearances most diverse, but the underlying principles are few and simple. An article written in 1914 by one of us ("The Edinburgh System of Dental Anæsthesia," *British Dental Journal*, 1914, p. 458 *et seq.*) reduced the then recognized methods to four,

to which a fifth must now be added. They are as follows:

Hewitt's original method.
Teter's method.
The Guy-Ross method.
Gatch's method (not here to be described, but in some sense the forerunner of the Guy-Ross).
Sight-feed machines.

Hewitt's Method.

About 1886 the late Sir F. W. Hewitt started working at a combined gas and oxygen apparatus, and designed one which would permit of an approximately definite percentage of oxygen to be given.

Rumbold of Leeds worked at the same subject, and designed a similar apparatus, but with two bags.

Hewitt's complete apparatus consists of two nitrous oxide cylinders and one of oxygen, with a combined stand and union and double or centrically arranged rubber tubes for conducting the gases from the cylinders to the bags. The bags are really formed by putting a septum in one bag, and are connected with a regulating stop-cock, mixing chamber, and face-piece. Nitrous oxide cylinders of 50-gallon size are most convenient, one of these holding about 15 gallons of oxygen.

The foot-key of the N_2O cylinder being turned on, the gas passes to its special section of the bag through brass and rubber tubes of fairly large calibre. The tube for the oxygen is of smaller size, and lies within the other.

The compartments are of equal size, and are only separated by a common indiarubber septum. When filled they appear almost like a single bag.

The regulating stop-cock and mixing chamber are figured opposite.

The valves are made of thin sheet-rubber, and the same remarks that were made about those in the ordinary nitrous oxide apparatus apply to them.

They are arranged to act most efficiently when the main expiratory valve is kept as horizontal as possible. If the patient's head is thrown far back and the apparatus tilted, they will not act so well.

The production of anæsthesia by means of nitrous oxide and oxygen is a most delicate process, much more so than simply administering nitrous oxide, and the most trifling defects in the apparatus are liable to interfere with results. Great care is needed in putting the apparatus together, in handling it, and seeing that it is in perfect working order.

In regard to the relative proportions of nitrous oxide and oxygen which the apparatus is capable

of furnishing, much will depend on the degree of distension of the bags during the inhalation, whether they are kept of the same size or not, and at the same time each apparatus possesses slight peculiarities of its own.

Hewitt's original pattern of gas and oxygen apparatus had two separate bags and tubes, and Rumbold's apparatus is now made in this way.

The apparatus is necessarily more bulky and unwieldy, but is less likely to get out of order than the new pattern, in which the occurrence of leakage from bag to bag through the septum is difficult to detect, and may cause confusion and lead to poor results.

The Administration.

The bags should be half filled with their respective gases, and the face-piece very carefully adjusted. The patient is instructed to breathe freely in and out through the mouth, and when good breathing has been established the indicator should be turned to '2.' Nitrous oxide with 2 per cent. of oxygen is then being administered. If a large percentage of oxygen is given at the start, excitement is apt to occur. In two or three seconds the indicator may be turned to '3,' and then to '4,' the bags being meantime kept as

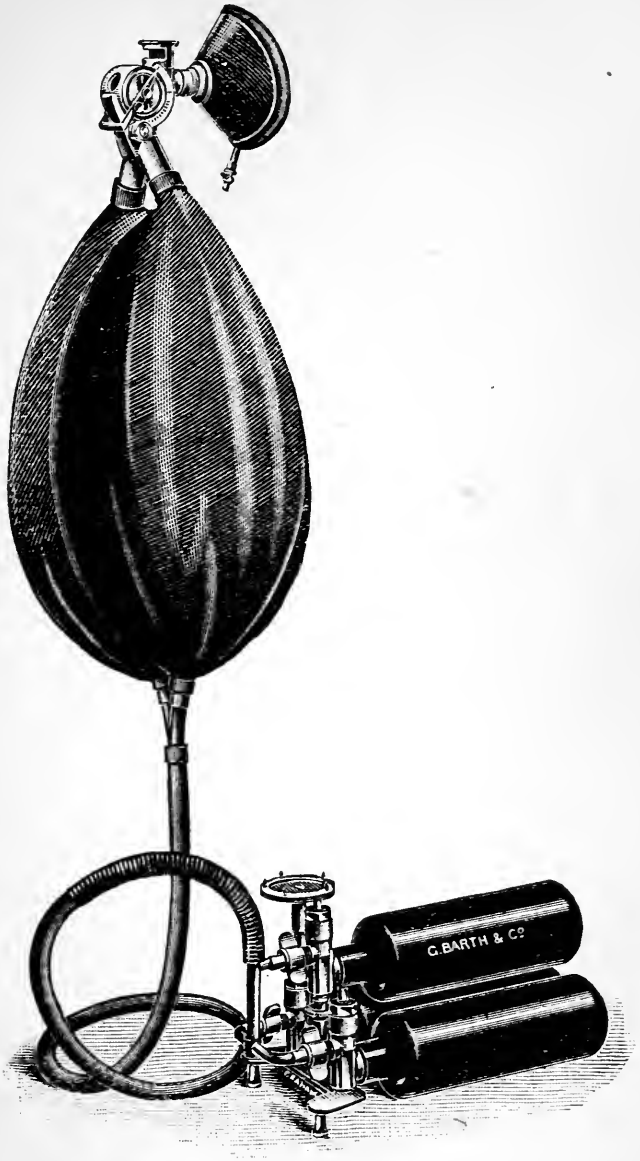

FIG. 14.—HEWITT'S GAS AND OXYGEN APPARATUS.

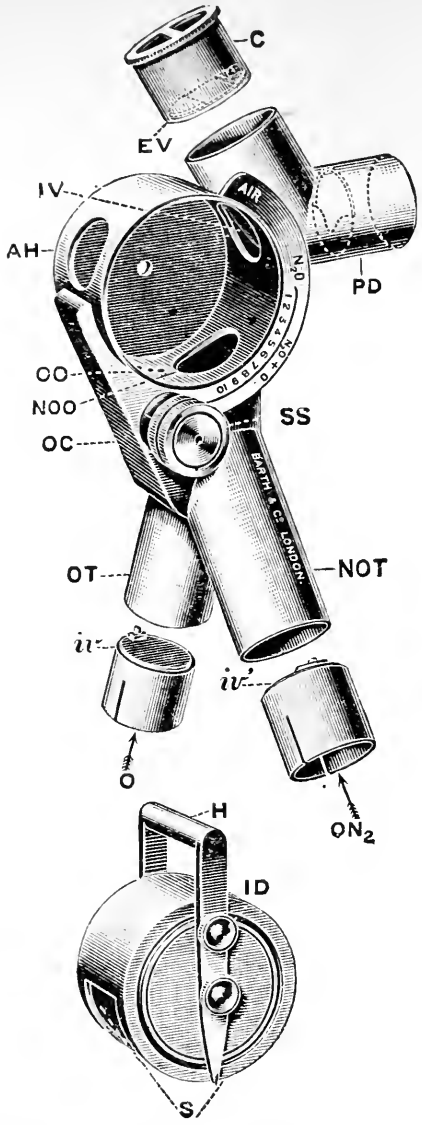

FIG. 15.—HEWITT'S GAS AND OXYGEN STOP-COCK IN PIECES.
(From Hewitt's 'Gas and Oxygen,' Ash.)

NOT, Nitrous oxide tube; NOO, orifice of same; SS, supplementary stop-cock; C, chimney; Figures, per cent. of oxygen; OT, oxygen tube; OO, orifice of oxygen tube; ID, inner drum; AH, air hole; IV, main inspiratory valve; EV, main expiratory valve; H, handle with indicator; S, slot.

nearly as possible of equal size. It is rarely necessary to have to turn on more oxygen during an ordinary dental case, but more nitrous oxide is always required. If phonation or excitement occurs, the oxygen must on no account be increased, but diminished. Working the indicator on gradually in the course of the first minute, it should have got to about ' 8,' and, as a rule, a higher percentage than this is not required in dental work.

In female subjects and children this percentage will frequently be used, but for robust people a smaller percentage will be followed by better results.

The Period of Inhalation of Nitrous Oxide and Oxygen.

The time needed to secure a deep degree of anæsthesia varies with different cases.

Sir F. W. Hewitt, however, over a series of very carefully-timed administrations, found the period to be 110·5 seconds on the average, and the corresponding period of available anæsthesia averaged 44 seconds.

We thus find that, while just double the time is required as compared with nitrous oxide the anæsthesia obtained is only half as long again in duration.

Recovery of Consciousness

takes place more gradually than with nitrous oxide. The patient is usually a little more dazed, and nausea, or even vomiting and headache, are more common than after the inhalation of nitrous oxide gas alone. Pallor, feeble pulse, and faintness occasionally occur. Hewitt noted three cases of transient maniacal excitement.

The Advantages and Disadvantages.

When the patient is over sixty, has cardiac disease with imperfect compensation, is suffering from phthisis, or is very run down and anæmic, there is unquestionably a very distinct gain in combining oxygen in some proportion with the 'laughing-gas.' Hewitt's apparatus enables us to do this in a fairly definite way, as we know approximately the percentage of oxygen we are using. But practically one finds in dealing with such cases, that the ordinary nitrous oxide apparatus with a bottle of oxygen, fitted on the stand and used at discretion, answers every purpose.

Oxygen may also be administered along with nitrous oxide when using Paterson's apparatus, the administrator gauging the amount of oxygen by the patient's condition, degree of cyanosis, etc.

The great bulkiness of the gas and oxygen apparatus is certainly a drawback. The two dis-

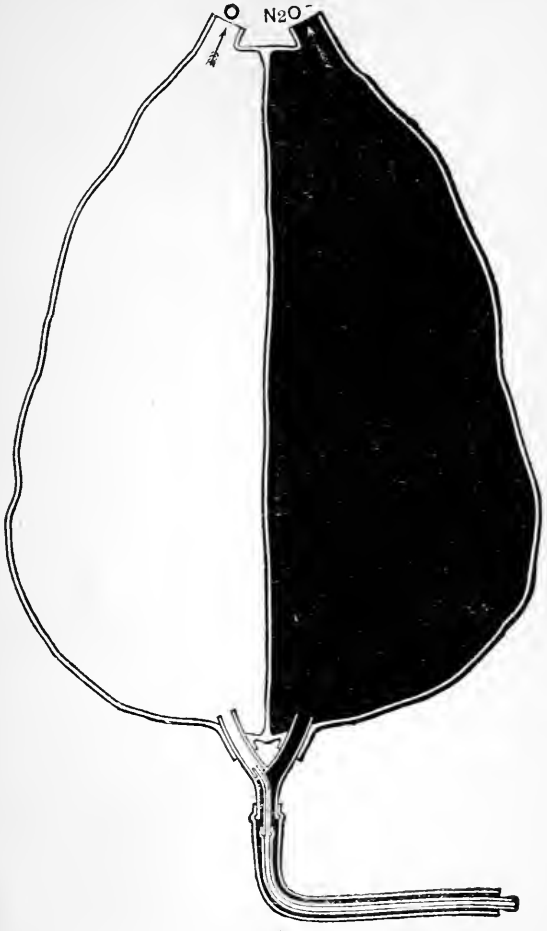

FIG. 16.—CROSS-SECTION OF HEWITT'S N_2O AND OXYGEN BAG.

tended bags are apt to frighten nervous children, and the apparatus as a whole is certainly more apt to get out of order than the ordinary single

gas apparatus. Further, it requires just as much practice to skilfully use the combined gases as to master the use of Paterson's nasal apparatus, an infinitely more portable and convenient mechanism, and one, moreover, by which unlimited quantities of air or oxygen can be made use of, and an anæsthesia of from half a minute to five minutes or more readily obtained after a reasonable amount of experience and practice.

The Teter System.

Teter brought out his machine in the first decade of this century. In it he introduced an entirely new principle. He removed the inspiratory valve from the mouth of the nitrous oxide bag, and designed the expiratory valve to open against a slight spring resistance, which resistance can be increased or decreased at will. Observe the results of this alteration of Hewitt's original scheme, and the added powers which it puts into the hands of the administrator. *Firstly*, by maintaining a full flow of gases from the cylinders, while at the same time increasing the resistance against which the expiratory valve has to open, it is possible to maintain a certain *positive pressure* of the gases upon the patient. A very little experience will convince an observer that in this positive pressure he has put at his disposal a

potent means of deepening gas-oxygen anæsthesia to a degree not possible without such help. That the method is capable of abuse and can be pushed a dangerous degree is obvious, but is no argument against its proper use in skilled hands. *Secondly*, by reducing the flow of gases while maintaining the tension of the expiratory valve, it is possible to cause part of each expiration to return into the nitrous oxide bag (which it will be remembered is unguarded by an inspiratory valve). By delicate manipulation of the two factors—tension of valve of expiration and the flow of gases from the cylinder—it is easy for the expert to arrange for just that degree of rebreathing which is beneficial to the patient, and having reached the correct adjustment, to maintain a good, even anæsthesia without further tap-handling. This was undoubtedly a great advance.

Designing his machine, as he did, on a substantial stand, not intended to be carried about from house to house, Teter had room for several useful additions, notably a chamber in which the gases are heated before being inhaled, and another in which a little ether vapour may be added to the gases in cases where such addition was considered desirable.

Numerous other American machines have been introduced, containing the same principles. Of

these we shall mention two. The CLARKE was devised especially for administration of the gases by the nasal method, the maker's pamphlet advocating its use for the production of the state known as *analgesia*. This is a stage reached before the loss of consciousness. In it sensitive dentine can be drilled and even live pulp cavities cleaned out, without the causation of pain to the patient. By using a mixture rich in oxygen delivered at low pressure, the state of analgesia can be prolonged for a considerable time. It is obvious that the least change in the conditions, however, may carry the patient into anæsthesia, a point with which one has to reckon.

The CHIO MACHINE represents another recent attempt to improve gas-oxygen methods. In this instrument the essential point is the introduction between the cylinder heads and the reservoir bags of pressure gauges, and of means to dam back the flow of gases, and thus to produce a more even flow into the reservoir bags. When acting well, this system certainly gives more security than others for the maintenance of a level anæsthesia, but all depends upon the gas-tightness of the connections—not an easy point upon which to be sure of uniform success. Probably the easiest way to secure the desired steadiness of flow with any machine is to use cylinders of large capacity,

and to make provision for warming the heads of the cylinders. Freezing of the orifices through which the gases flow is fatal to evenness of flow.

All the machines so far mentioned in this group are large and not intended for moving from house to house. An attempt has been made to modify the Hewitt instrument so as to combine its comparative mobility with the advantages of the new principles introduced by Teter. This has been done by removing the inspiratory valve from the mouth of the nitrous oxide bag, and fitting the expiratory valve with a cap, which can be rotated in such a way as to put the valve out of action altogether when desired. This modification, known as BURN'S, which can be carried out easily upon any existing Hewitt instrument, enables one to secure rebreathing, but would be greatly improved by substituting for the existing expiratory valve one of the Teter type, by the use of which positive pressure could be obtained. One of us used a Burns in France for some months, and was very pleased with it.

THE GUY-ROSS METHOD.

The Guy-Ross method of giving gas and oxygen is a distinct improvement on that of Hewitt. The apparatus is designed on the principle that a known and absolutely definite quantity of oxygen

is blended with a known quantity of nitrous oxide. The method is simple and the results uniform. Rebreathing is allowed to a definite extent. The essential parts of the apparatus are as follows:

A three-bottle gas-stand with an upright crutch having two 100-gallon cylinders of nitrous oxide and one 30-gallon cylinder of oxygen, all operated by foot-keys. There is a 2-gallon bag with a **Y** tube for admission of the nitrous oxide by one limb from the cylinders, and a 1-gallon bag into which oxygen is admitted by the other limb of the **Y**.

There is the usual three-way stop-cock, which should be provided with an ethyl chloride attachment between bag and face-piece. In the continuity of the tube from the oxygen bag is fixed a rubber pump as used for a Higginson syringe, which, when compressed by the hand, draws at each expansion a known quantity of oxygen from the 1-gallon oxygen bag and drives it into the nitrous oxide bag.

The cycle of administration is as follows:

1. Nitrous oxide with as much oxygen as is desired (measured with accuracy and varied according to circumstances) is passed into the 1-gallon bag.

2. The patient rebreathes the mixture for as long as is desirable. As the oxygen factor is

consumed by the patient it is kept up by gradual additions from the pump.

3. In a period which varies, but which averages about two minutes, the CO_2 in the bag rises to 10 or even 12 per cent. At this point the valves are put in action, and the contents of the bag expired into the outer air.

4. The valves are again thrown out of action and the bag refilled with an appropriate mixture of the gases.

In the practical conduct of a case we first fill the gallon oxygen bag. The bulb is squeezed twice to secure any air being expelled before we turn on the oxygen. The three-way tap is put to air, and the N_2O bag filled. Careful adjustment of the face-piece is now called for, and no leakage of air must be allowed. The tap is turned full on to 'No valves' at the end of expiration. Rebreathing is usually allowed for fifteen seconds, and oxygen then pumped in. Each squeeze of the bulbs pumps in 2 ounces of oxygen. It is advisable to increase the percentage of oxygen during the administration, and we find that two compressions give $1\frac{1}{4}$ per cent. of oxygen. If two compressions are given every ten seconds, at the end of sixty seconds the patient will be receiving $7\frac{1}{4}$ per cent. of oxygen. If two compressions are given every fifteen seconds, the mixture at the

end of a minute will be 5 per cent. of oxygen. It is seldom necessary to give more than two compressions in ten seconds, and seldom wise to give less than two in every fifteen seconds.

The period of induction seldom exceeds eighty seconds, but it may be longer in special cases, when there is no risk in continuing the mixture. No cyanosis should be allowed to appear, but if by chance it threatens, oxygen should at once be pushed.

The period available is about thirty seconds from the removal of the face-piece.

It is just here that Bellamy Gardner brought his ripe judgment and knowledge to bear on the subject, and devised an almost perfect anæsthesia, induced and maintained by the nasal method continuously. He adapted Hewitt's principle of giving definite percentages of oxygen to the nasal apparatus of Coleman, improved by Paterson and Nash. Nash's improvement, it may be said in passing, consisted in improving the rather unadaptable nose-piece of Paterson's first apparatus, making several sizes 'money-lenders and others' of soft flexible copper, and also fitting an expiratory valve, which latter was a great advance. Gardner arranged that the tubes from this led to a Hewitt's gas and oxygen mixing chamber.

His rubber bag differs from Hewitt's, being

adapted from one devised by A. G. Levy, with the small oxygen bag contained inside the larger N_2O bag. Such an arrangement tends to the equalizing of the pressure of the gases, if it does not entirely secure it. It is important to avoid distending the oxygen bag if an equal pressure is to be maintained.

Both bags are connected with the gas and oxygen cylinders respectively by a piece of concentric tubing. By reversing the 'valve chimney' at the proximal end of the nose-piece the expiratory valve is put out of action, so that rebreathing is allowed.

Beginning with 6 per cent. of oxygen, this element in the mixture is slowly increased up to 15 per cent., and after a period of induction of ninety seconds anæsthesia is usually complete. The outer or N_2O bag should be replenished from time to time, and kept full, but not allowed to become distended any more than the one which it contains.

The special mouth-cover may be required during the period of induction if the patient inspires too freely through the mouth. One gallon of oxygen usually suffices, so that the replenishing of this bag is usually unnecessary, but the pressure in the nitrous oxide bag must be kept up nd in some cases made a little plus. The oxygen, of course, takes the place of the

air valve with which we regulate the colour in continuous nasal N_2O anæsthesia, and by carefully regulating the supply according to the patient's requirements a practically normal colour may be maintained throughout, with complete absence of stertor—merely quiet nasal respiration being noticed usually. The pupils become moderately contracted, with a sluggish corneal reflex. The pulse inclines to be quicker and satisfactory in volume and character generally. If the nitrous oxide is pushed and given under any plus pressure some degree of stertor may be noticed, but is easily avoided. The moment to-and-fro nasal breathing is established the N_2O gas should be diminished.

Properly used, this apparatus provides the most perfect type of anæsthesia available from nitrous oxide, with an extraordinary degree of safety, and *almost unlimited period for operative procedure*, and a minimum disturbance of the patient's equilibrium both during and after the anæsthesia.

Sight-Feed Machines.

The sight-feed principle could be introduced into any machine, but its great advantage lies in the fact that by it we secure control over the pressure of each gas, and therefore of the richness

in oxygen of the mixture, at the very beginning, as it were, and that the remainder of the apparatus may therefore be of the simplest possible type. Indeed, the ordinary three-way tap, face-piece, and 2-gallon bag (Fig. 10), as used for giving gas unmixed with oxygen, may with a sight-feed fitted to each cylinder serve admirably for gas and oxygen. The sight-feed consists of a glass chamber roofed in by a metal plate perforated by three pipes, two of entry and one of exit. Each gas is led through its appropriate pipe into the chamber, which is filled three-quarters full with water. Each pipe is perforated at the sides, and it will be obvious that if the pressure of gas, whether oxygen or nitrous oxide, be great, bubbles will be seen escaping from the side of supply pipe right down to the bottom of the water, while if the pressure be reduced bubbles will be seen only from the orifices in the upper part of the tube. Upon the surface of the water the two gases meet and mix, and pass from the chamber by the third tube, that of exit, towards the patient. The anæsthetist trains his eye to judge, from the deepest level at which he can observe bubbles from each of the tubes of entry, at what pressure each gas is escaping—that is, to all intents and purposes, how much of each gas is passing from the cylinders into the inhaler from which the patient

is breathing. By manipulation of the taps at the cylinder heads he can secure the mixture which he desires. It is to our mind certain that this method has a large future before it, particularly if combined with an instrument fitted with an expiratory valve of the Teter type, with its power of causing positive pressure.

It will be noticed that many of the methods and instruments above described hail from the United States, and we have here the greatest pleasure in rendering our homage to the sterling work done in gas-oxygen by American anæsthetists, and to the great advances they have made in the older methods. But we must not omit to mention that several British makers, notably Messrs. Claudius Ash and Co., have introduced models embodying the most valuable of the recent advances.

Having taken our reader through this brief survey of possible methods and appliances, we may now ask him to turn to the *practical question of the purpose for which he requires a gas-oxygen apparatus*. Upon the answer to that question will largely depend his choice of individual instrument.

If he desires it to meet the requirements of extraction work only, and if he intends to adopt the principle of the single dose, doing as much under that dose as is possible and readministering

upon a later occasion if necessary, then the Guy-Ross method has much to recommend it. If, however, he desires to use nasal methods, and to essay the practice of analgesia, then he must select either a Teter, a Clarke, or one of the similar instruments made by British firms such as Ash and Co. All these are, however, immobile. For a machine intended for frequent transportation Bellamy Gardner's apparatus (see p. 140) will be the most suitable choice.

Nitrous Oxide and Ethyl Chloride in Sequence.

This combination has several advantages, chief amongst which is the fact that after-sickness is less frequent than after ethyl chloride alone, only occurring in about 5 per cent. of the cases. Further, many patients prefer to lose consciousness by means of gas, the odour being less perceptible and more pleasant than that of ethyl chloride. Guy's apparatus described under Ethyl Chloride does very well for the administration, and we must confess a liking for that devised by the late Sir F. W. Hewitt, which consists of a 2-gallon gas-bag with two entrant tubes at the lower extremity, one for the gas and the other for attaching a phial of ethyl chloride.

In Guy's apparatus the N_2O is admitted by

the feed-tube attached to the angle-mount by a ball-and-socket joint. In the perpendicular part of the three-way tap there is a hole marked with

FIG. 17.—GUY'S ETHYL CHLORIDE INHALER.

an arrow, and when this corresponds with the pointer in the bag-mount the holes in the latter are in exact register.

In using the apparatus, the tap is turned to 'Air.' Gas is let into the bag until it is full, and the bag-mount is turned around a quarter of a circle to close the outlet. The gas-supply is now disconnected. The ethyl chloride tube, kept in the dependent position, is now attached to the feed-tube.

The patient may be seated or lying down, but, generally speaking, in dental work the sitting-up posture is preferable, being more convenient to the operator. The patient's legs should be extended, with the hands resting on the lap. The anæsthetist should grasp the face-piece firmly in his right hand, standing on the left side of the patient, and passing his arm around the patient's neck and the head-piece of the chair. The face-piece must be carefully and firmly adjusted to the patient's face, and at the end of an expiration the tap is turned to 'No valves.' After six complete respirations the ethyl chloride supply-tube is tilted up and the drug poured into the bag.

The patient is then allowed to breathe the mixture for from twenty-five to thirty seconds, and should then be ready for the operation to begin. Time spent in holding the breath by nervous patients, or those who find the smell unpleasantly pungent, must not be counted. During the

twenty-five seconds mentioned the patient should be actively breathing. The amount of ethyl chloride introduced into the bag should never exceed 5 c.c., and rarely be more than 3 c.c. For the very large majority of cases this will be sufficient. It is important that the bag is dry, and that the temperature of the operating-room is not below 60° F.

This mixture is a single-dose anæsthetic, and should not be repeated at a sitting, or sickness is certain to result.

The Administration of Ethyl Chloride and Ether in Sequence.

This sequence is a very useful one in dental surgery for cases where there are more than six teeth to extract, or where there are a number of roots to remove over which some amount of difficulty is anticipated. The time afforded will, of course, almost entirely depend on the period for which the patient is made to inhale the ether. It is easy to obtain an anæsthesia of from two and a half to ten minutes by means of this method without having to reapply the face-piece. The chief advantage which this combination possesses over gas and ether is the greater portability of ethyl chloride compared with nitrous oxide gas. The apparatus itself is, of course, much less

bulky also, simply consisting of a Clover's inhaler, with the slight modification already described for introducing the ethyl chloride.

This sequence is somewhat easier to give than 'gas and ether'; but in deciding between the two methods it must be remembered that 'gas,' being tasteless, is more agreeable to the patient as the first member of a sequence than the rather sickly smelling ethyl chloride, and that 'gas and ether' holds a long and unrivalled record for almost absolute immunity from fatalities.

The dose of ethyl chloride is introduced into the bag just before the administration, and need rarely exceed $3\frac{1}{2}$ c.c., and 1 ounce of ether is introduced into the ether chamber. If the patient shows signs of recovery from the ethyl chloride before the ether has exerted its action, a further 2 c.c. of ethyl chloride may be sprayed in. This will only be required in the case of strong or alcoholic men.

In conducting the administration, the patient should be allowed to take six or eight breaths of the ethyl chloride, and then the ether should be turned slowly on. The administration should be carried to the point of the abolition of the corneal reflex and moderate dilatation of the pupils; but in cases where a long anæsthesia is desired the ether may be pushed without fear,

FIFTY CASES OF GAS AND ETHYL CHLORIDE ANÆSTHESIA (GUY'S METHOD).

Number.	Patient (Sex and Age).	Duration of Inhalation.		Available Anæsthesia.	Ethyl Chloride Used.	Teeth Extracted.	Phonation.	Pupil.	Cyanosis.	Stertor.	Remarks.
		Gas.	Gas and E.C.								
		secs.	secs.	secs.	c.c.						
1	M. 16	25	45	75	3	7	o	5 mm.	o	o	Large bag; indeterminate quantity of gas, 1-2 galls.
2	F. 25	25	45	45	3	5	o	4 ,,	o	o	—
3	F. 23	25	50	60	3	1	going under	4 ,,	o	o	—
4	F. 25	25	65	75	3	15	,, ,,	4 ,,	o	o	—
5	F. 17	30	30	45	3	3	,, ,,	4 ,,	yes	o	One breath of air admitted.
6	M. 23	15	50	60	3	5	,, ,,	normal	o	o	—
7	F. 15	25	45	65	3	2	o	,,	slight	o	One breath of air admitted.
8	F. 19	10	40	80	3	3	yes	4 mm.	o	o	—
9	F. 14	15	35	60	3	8	o	4 ,,	yes	o	—
10	F. 21	10	40	80	3	8	o	4 ,,	slight	o	—
11	F. 18	10	50	85	3	4	o	normal	,,	o	—
12	F. 24	10	90	85	3	9	yes	,,	,,	o	—
13	F. 25	10	80	90	3	8	o	4 mm.	,,	o	—
14	F. 23	10	75	35	2	2	yes	normal	,,	o	—
15	F. 21	15	60	60	3	3	o	4 mm.	,,	o	Hysterical patient.
16	F. 23	10	55	80	3	12	yes	4 ,,	,,	o	—
17	F. 16	10	50	60	3	2	,,	5 ,,	o	o	Very anæmic.
18	F. 16	10	45	80	3	3	o	4 ,,	o	o	—
19	F. 16	10	40	60	3	2	o	5 ,,	slight	o	Small bag; 1 gall. of gas.
20	F. 17	15	90	60	3	3	o	5 ,,	o	o	—
21	F. 30	10	53	75	3	12	o	5 ,,	slight	o	—
22	M. 14	10	50	65	3	5	o	normal	o	o	—
23	F. 15	10	50	70	3	7	o	5 mm.	very slight	very slight	—
24	F. 20	10	40	60	3	6	o	4 ,,	o	o	Phthisic.
25	F. 32	10	50	70	3	5	o	4 ,,	o	o	—

26	M. 25	10	45	60	3	2	yes	5 ,,	yes	slight		—
27	F. 21	10	40	75	3	2	o	5 ,,	slight	o		Involuntary micturition.
28	F. 21	10	75	90	3	2	o	5 ,,	,,	o		—
29	F. 22	10	40	65	3	3	o	5 ,,	,,	o		—
30	M. 21	10	55 40*	35	3	19	o	4 ,,	yes	yes		Marked muscular rigidity.
				150	5	19	o	4 ,,	,,	,,		,, ,, ,,
31	M. 20	10 air	40 45 45	85	5	6	o	4 ,,	slight	o		Tongue fell back, obstructing respiration at 40 secs.
32	F. 20	10	45	100	3	5	yes	4 ,,	o	slight		—
33	M. 25	10	60	65	5	11	o	5 ,,	slight	,,		—
34	F. 18	10	50	70	3	6	yes	4 ,,	o	,,		—
35	F. 15	10	45	70	3	4	o	5 ,,	slight	o		—
36	F. 19	15	45	80	3	8	o	5 ,,	,,	o		—
37	F. 22	15	55	95	3	9	o	5 ,,	o	o		—
38	F. 47	15	50	85	3	12	o	4 ,,	yes	o		Air at 35 secs., Hewitt's apparatus.
39	M. 22	10	40	70	3	1	o	4 ,,	slight	o		—
40	F. 50	10	65	120	5	12	o	5 ,,	o	o		Anæmic woman.
41	M. 38	15	65	70	5	9	o	normal	yes	o		—
42	F. 26	15	50	55	3	14	yes	5 mm.	slight	o		Breath of air at 40 secs. Feeble, neurotic.
43	F. 18	15	65	60	3	12	,,	5 ,,	,,	o		—
44	F. 31	15	60	60	3	9	,,	4 ,,	yes	yes		—
45	F. 22	15	90	120	3	18	,,	4 ,,	,,	,,		Breath of air at 50 secs. Considerable outcry and resistance, but complete analgesia.
46	F. 19	15	65	70	3	9	o	4 ,,	slight	,,		Breath of air at 40 secs.
47	F. 18	15	45	60	3	4	o	4 ,,	yes	o		—
48	F. 14	15	25	60	3	3	o	normal	o	o		—
49	F. 22	15	55	65	3	6	yes	4 mm.	slight	o		—
50	F. 17	15	65	65	3	9	,,	4 ,,	,,	o		Breath of air at 50 secs. Great outcry, but analgesic; very noisy during administration.

* Re-applied ethyl chloride.

and a well-dilated pupil with deep anæsthesia be established before the face-piece is withdrawn.

Nitrous Oxide, Oxygen, and Ethyl Chloride Sequence.

This method has been devised by Mr. Guy and one of ourselves for use in cases where the period available in gas and oxygen anæsthesia is not sufficiently great, and where the anæsthetic is given, not by a skilled anæsthetist, but someone with less wide experience, such as a dental practitioner or a dental surgeon. It is simply an amplification of the N_2O and oxygen method described on pp. 143 and 219.

Ethyl chloride is used as an adjuvant to the gas and oxygen. The apparatus is identical with that described under Gas and Oxygen, but has Guy's ethyl chloride attachment to the stop-cock.

Previous to the adjustment of the face-piece, the gas and 3 c.c. of ethyl chloride are introduced into the bag and the ethyl chloride attachment respectively. After five or six respirations or rebreathings, the patient having been warned not to mind the smell, the ethyl chloride is introduced into the gas-bag in the usual way. Oxygen is added as indicated by the colour of the patient's face. The induction of narcosis

is more rapid when the mixture of gases and ethyl chloride is rebreathed, the average time being sixty to seventy seconds. Guy bases the undoubted success of this method on the fact that the minimal combination of two drugs of different kinds is very much less than the minimal narcotic dose of the same two drugs.

On this principle, if the time available by this method be insufficient, 3 c.c. of ether can be added, and this at once delays the evaporation of the ethyl chloride and prolongs the anæsthesia. This is, of course, merely an alternative to rapidly introducing the Clover chamber between face-piece and gas-bag.

Guy has found this combination of gases and ethyl chloride of the greatest value in hospital practice, and highly economical. Quite unfavourable types of patients can be anæsthetized rapidly and with complete certainty, including 'strong athletic males, soldiers, navvies, and alcoholics'—the last of both sexes.

Very small doses of ethyl chloride are required for children. One c.c. is enough for a child of three to four years old, and 2 c.c. for one of ten or thereabouts. Oxygen should be introduced almost from the start, and the ethyl chloride introduced in from ten to fifteen seconds.

Gas and Ether Administration.

The apparatus required is as follows:

A Clover's portable inhaler, with a good medium-sized Barth's face-piece and a 3-gallon gas-bag fitted with an ordinary three-way stop-cock; 4 or 5 feet of ½-inch stout rubber tubing joining the lower end of the gas-bag to the nozzle of a two-bottle (angle pattern) gas-stand fitted with pedal keys.

It is convenient to have a small vulcanite tap between the tubing and the gas-bag, so that, if it is desirable, the bag may be filled with nitrous oxide and detached. For general purposes 50-gallon gas-bottles will be found most convenient, and it is well to have three or four in stock, so that an empty one can at once be replaced. In turning on the gas, always use the same bottle—the right or left—until it is exhausted, and so avoid the possibility of the two running out at the same time.

A filler is always provided with a Clover's inhaler, which just contains 1½ ounces; personally, I never use this, but find it more convenient to keep a supply of ether in a *corked* medicine bottle, from which it is easy to measure off about 1½ ounces (three tablespoonfuls), and then 'jumping' of the stopper, which so often is a nuisance in a warm room, is avoided. When filling the

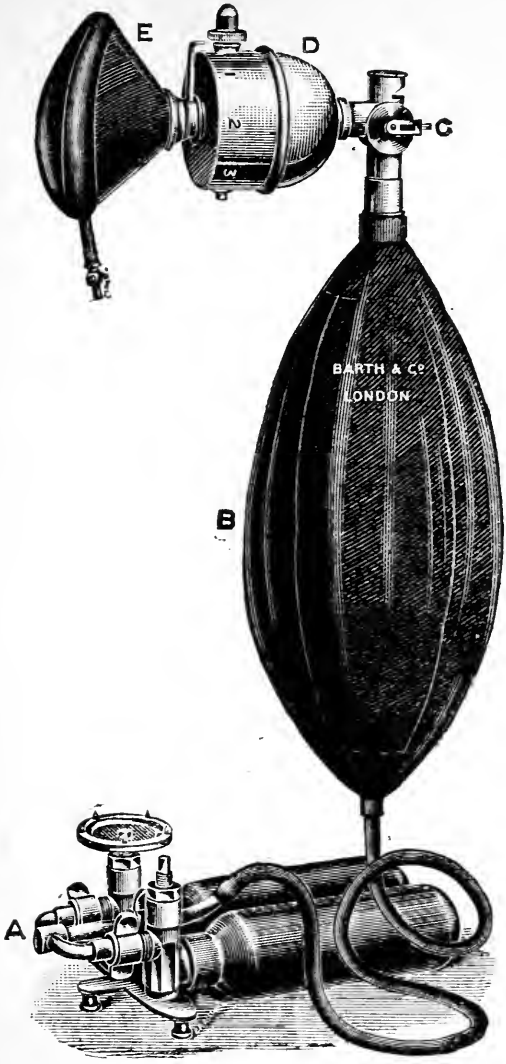

FIG. 18.—GAS AND ETHER APPARATUS.

ether-chamber, always turn the index on a little to ' 2 ' or ' 3,' as otherwise the ether bubbles back and is wasted.

The figures 0, 1, 2, 3, and F (full), marked on the cylindrical portion of the chamber, have the following significance, as indicating the proportion of the air respired which is passing into the ether-chamber. When the indicator stands at '0,' it signifies that the patient is breathing to and from the bag—that is, either pure air or nitrous oxide—and that none of the air which is passing backwards and forwards from the patient's mouth to the bag is being allowed to traverse the interior of the ether-chamber on its way.

With the indicator at '1,' one part in every four is circulating over the ether, while the other three parts are circulating backwards and forwards as before. With the indicator at '2,' two-fourths, or one-half, are entering the ether-chamber; at '3' three-fourths; and at 'F,' or full, all the breath is passing into the ether-chamber on its way to and from the bag.

The Barth three-way tap is similar to that used for ordinary gas administration, the structure of which is explained on p. 54. When filling the bag, the tap is set at 'Air'; at the start of the inhalation and for about six breaths at 'Valves,' and then it is pushed on to 'No valves.' By that time the bag will be about half empty, and should be partially recharged with nitrous oxide.

Guy's practice is to turn the tap to 'No valves'

from the start; this is contrary to Hewitt's custom, with which the author is inclined to agree. By allowing the patient six or seven breaths through the valves, a large amount of air and carbonized air is got rid of, which would, so to speak, dilute or adulterate the nitrous oxide if expired into the bag, and make the anæsthesia produced more of an asphyxial type than a pure nitrous oxide narcosis, and headache and nausea more common sequelæ. By getting rid of the tidal and residual air, etc., one rapidly gets the patient under the influence of the gas. On the other hand, later on in the induction of anæsthesia there is no objection, but quite the contrary, to turning back the index to 'Air,' thus giving the patient a breath of air to lessen cyanosis, and this will to no appreciable extent shorten the period of available anæsthesia.

Simultaneously with the setting of the tap at 'No valves' the ether vapour may be turned on. This will generally be found to be about twenty-five seconds from the start. The rotation of the chamber is begun very slowly, and if the patient shows no sign of choking or resenting, the vapour is continued more boldly until the indicator stands at '4' and 'F.' If coughing or holding of the breath occurs, at once switch the chamber back; 'Reculez pour le mieux sauter,'

and, on regular breathing being re-established, increase the rotation. Never *force* the ether vapour and so cause respiratory hesitancy, which will interfere with the production of a good, quiet anæsthesia, for the dulling of the patient's cough reflex, etc., with the nitrous oxide is merely a question of time.

Some degree of lividity is usually associated with the establishment of deep anæsthesia, unless a good deal of time has been taken over the induction and air freely admitted. In dealing with ordinary healthy patients, and as a matter of routine, however, the administrator can safely disregard this until it is at all marked or associated with stertor, when the tap should be at once turned to 'Air' and two or three respirations allowed, which will cause the prompt disappearance of the cyanosis.

Of course, where the patient is not robust, is anæmic, or suffering from any cardiac trouble, especially 'strained' or muscularly feeble heart, more care than usual is needed. Anæmic patients have a marked tendency to become rapidly cyanosed, and then stertor, rigidity, and opisthotonos ensue, necessitating the withdrawal of the anæsthetic, possibly the use of a mouth wedge, but at any rate a liberal allowance of air.

The establishment of anæsthesia may be recog-

nized from the loss of conjunctival reflex (the patient does not 'wink' when his eyeball is touched), from regular automatic breathing, a more or less dilated pupil and muscular flaccidity, the arm dropping limply at the patient's side if raised and let go. Very robust men, alcoholics, and hysterical or neurotic females are not usually good subjects for gas and ether, for they sometimes get excited when half 'over,' and struggle violently or shout and scream. With a little care, however, these demonstrations may be avoided by anticipating them, and getting the patient more fully under the gas before turning on ether.

It is of extreme importance to see that no leakage of air occurs throughout the administration from the apparatus being out of order and leaking, or from a badly-adjusted face-piece. The uncontrolled admission of air in this way invariably prolongs the period required to induce anæsthesia, and frequently causes struggling and excitement.

It is well to bear in mind that both before and after the extractions have begun the patient may utter sounds and perform co-ordinated movements, although unconsciousness and analgesia are perfectly maintained, and if there are friends in the operating-room, or near, it will be wise, in some cases, to explain this.

The duration of the anæsthesia is an entirely variable quantity, and will depend on the duration of the administration, the amount of ether

FIG. 19.—GUY'S ARRANGEMENT FOR ADMINISTERING GAS AND ETHER.

inhaled, and the type and constitution of the patient.

If the administration be properly conducted,

and one minute and a quarter to one minute and a half be allowed to elapse from the moment of the adaptation of the face-piece, an anæsthesia of at least a minute should be available, allowing sufficient time for a moderately expert dentist to extract a couple of difficult teeth or six or seven easy ones. It is always well to leave some margin, however, and the 'gas and ether sequence' may be administered for two, three, four, five, or ten minutes, according to the time which it is expected the extractions will take to effect. Of course, when the ether is pushed in this way, the patient passes into a condition of deep anæsthesia, and the responsibility of the case becomes so much the greater. The pupils dilate up and become fixed—that is, do not contract on raising the eyelid; the breathing is deep, regular, and somewhat stertorous; the patient's face flushes, and free perspiration is sometimes seen. The patient is 'charged up' with a large dose of ether, just as he would be with a large dose of alcohol, and while there is really little more risk as regards his condition in the former than in the latter case, still, in view of the prolonged period of complete unconsciousness and the nature of the operative procedure, involving free hæmorrhage and possibly some obstruction in the airway, the administrator requires to have his wits

FIFTY GAS AND ETHER CASES TAKEN CONSECUTIVELY IN THE DENTAL DEPARTMENT, ROYAL INFIRMARY, EDINBURGH.

Sex.	Age.	Duration of Inhalation.			Available Anæsthesia.	Gas used.	Operation Performed.	Phonation.	Pupil.	Cyanosis.	Stertor.	Remarks.
		Gas.	Gas and Ether.	Total.								
		sec.	min. sec.	min. sec.	min. sec.	galls.						
1. Female	22	28	0 30	0 58	2 15	3	Extraction of 24 teeth and roots	none	5 mm.	slight lividity	none	4 inspirations of air given when inhalation had lasted 40 sec.
2. ,,	26	35	1 0	1 35	2 30	3	13 ,, ,,	,,	4 ,,	,,	slight	3 inspirations of air at 50 sec.
3. ,,	18	25	1 15	1 40	1 20	4	13 ,, ,,	,,	5 ,,	none	none	Drumming of heels during administration.
4. ,,	23	20	1 15	1 35	1 35	3	5 teeth	,,	4 ,,	,,	,,	
5. ,,	23	15	1 0	1 15	1 50	4	16 teeth and roots	,,	3 ,,	slight lividity	,,	1 inspiration of air allowed.
6. ,,	18	45	1 10	1 55	0 50	3	2 teeth	,,	3 ,,	none	,,	Patient nervous and excited; attempted extraction by student at Dental Hospital same morning. The time taken in operation was noted 50 sec.; anæsthesia lasted longer.
7. ,,	26	25	1 10	1 35	1 0	3	5 teeth	,,	4 ,,	very slight	,,	
8. Male	19	35	1 5	1 40	1 10	3	8 teeth and roots	,,	4 ,,	,,	,,	Patient sent from Ear and Throat; had had double McEwen performed for knock-knee 3 months ago. Some movement of left leg.
9. Female	27	35	1 35	2 10	1 20	3	6 teeth	,,	3 ,,	none	,,	
10. ,,	20	30	1 5	1 35	2 40	3	20 teeth and roots	,,	4 ,,	slight	,,	Trade movement observed—working sewing-machine.
11. ,,	11	30	0 35	1 5	1 10	3	7 ,, ,,	,,	5 ,,	none	,,	
12. ,,	19	25	1 0	1 25	1 20	3	7 teeth	,,	4 ,,	,,	,,	
13. ,,	28	25	1 55	2 20	2 5	3	8 ,,	,,	4 ,,	,,	,,	
14. ,,	17	25	1 20	1 45	1 55	4	3 ,,	,,	4 ,,	,,	,,	Pleasant dreams of night-schools and singing-class.
15. ,,	20	25	0 55	1 20	1 25	4	6 ,,	,,	4 ,,	,,	,,	
16. ,,	42	25	1 5	1 30	0 55	3	3 ,,	,,	3 ,,	,,	,,	Fat, corpulent patient.

17.	„	26	25	1	5	1	30	1	40	3	8 lower roots	„	4 „	„	„	
18.	„	28	25	1	5	1	30	1	45	3	8 teeth	„	4 „	„	„	
19.	„	21	25	1	7	1	32	1	5	5	7 „	„	4 „	„	„	
20.	„	17	25	0	55	1	20	1	15	3	13 „	„	3½ „	„	„	
21.	„	12	30	0	30	1	0	1	5	3	6 roots	„	4 „	„	„	
22.	„	26	27	0	55	1	22	1	0	3	3 teeth	„	3 „	„	„	
23.	„	19	25	1	20	1	45	1	25	3	10 teeth and roots	„	3 „	slight	„	Slight lividity at close of administration.
24.	„	25	25	0	45	1	10	1	0	3	2 lower molars	„	4 „	none	„	
25.	„	24	25	0	50	1	15	1	30	3	4 „ „	„	3 „	slight	„	
26.	„	19	25	0	57	1	22	0	55	3	2 teeth	„	4 „	none	„	
27.	Male	22	25	1	10	1	35	1	10	3	4 teeth and roots	„	4 „	slight	„	Case of phthisis pulmonalis.
28.	Female	22	25	1	5	1	30	1	15	3	12 teeth	„	3½ „	none	„	A series of cases in which the anæsthesia was quiet and uneventful.
29.	„	28	25	1	25	1	50	1	25	3	2 „	„	3 „	„	„	
30.	„	21	25	1	15	1	40	1	45	3	12 „	„	5 „	„	towards end	
31.	„	36	25	1	15	1	40	2	20	3	15 teeth and roots	„	4 „	„	slight	
32.	„	19	25	0	55	1	20	1	10	3	9 „ „	„	4 „	„	none	
33.	„	18	25	0	50	1	15	1	0	3	4 teeth	„	3 „	„	„	
34.	„	19	25	0	55	1	20	1	5	3	6 „	„	4 „	„	„	
35.	„	20	25	1	0	1	25	1	5	3	6 teeth and roots	„	5 „	„	„	
36.	„	17	25	0	45	1	10	1	15	3	3 teeth	„	5 „	„	„	Case of phthisis pulmonalis.
37.	„	18	25	0	40	1	5	1	5	3	3 „	„	4 „	„	„	„ „ „
38.	„	19	25	0	55	1	20	1	10	3	6 „	some	4 „	„	„	
39.	„	26	25	0	55	1	20	1	5	3	4 „	none	4 „	„	„	Patient in bed in ward.
40.	Male	30	25	1	17	1	42	2	0	3	11 teeth and roots	„	4 „	slight	„	2 breaths of air at 1 min.
41.	Female	18	23	0	50	1	15	1	10	3	6 „ „	„	4 „	cyanosis	„	3 breaths of air at 40 sec.; patient holding breath.
42.	„	22	25	0	50	1	15	1	20	3	5 teeth	„	4 m.	slight	„	Some excitement, due to admission of air by badly adjusted face-piece.
43.	„	17	25	0	40	1	5	1	0	3	5 „	„	3½ mm.	„	„	
44.	„	23	25	0	55	1	20	0	50	3	3 „	„	3½ „	none	„	
45.	Male	14	25	0	55	1	20	0	50	3	2 „	crying	3 „	cyanosis	slight	Resisted administration and took it badly, holding breath and struggling; 3 breaths of air at 25 sec.
46.	Female	18	25	0	50	1	15	0	50	3	6 „	none	3 „	none	none	
47.	„	16	25	0	50	1	15	1	15	3	3 „	„	3 „	very slight	„	
48.	„	15	25	0	55	1	20	1	15	3	7 „	„	5 „	none	„	
49.	„	18	25	0	50	1	15	1	10	3	5 „	„	5 „	lividity	„	Lividity just at end of administration.
50.	„	26	25	1	0	1	25	1	45	3	12 teeth and roots	„	3 „	none	„	

about him. When patients require extractions which will necessitate the maintenance of complete analgesia and unconsciousness for any period over two minutes, it is strongly advisable to have in a fully-qualified expert at anæsthetic work to assist, and take full charge of the anæsthetic.

Guy, for routine work, a vocates the administration of gas and ether just up to the stage of disappearance of the conjunctival reflex, so as to produce one and a half to two minutes of anæsthesia, and his teaching is to extract rapidly and do as much as possible in the time available, but if unable to complete the operation, simply get the patient back another day. Of course, when the patient lives near at hand, and especially when dealing with hospital patients, this will answer well; but, then, there are patients coming from a distance to be considered, and there are many people who do not like to undergo the dreaded ordeal of anæsthesia twice, or who, in colloquial language, desire the dentist to 'make a job of it' at the sitting! While there is a distinct advantage in only giving such an amount of ether as will not incapacitate the patient from going back to his occupation in three or four hours, the wishes of such patients can be readily met and at the same time the most difficult assortment of teeth stumps and roots—even 'lower

wisdoms '—may be extracted *tuto et jucunde*, with one full inhalation of ether.

We have personally sometimes afforded the operator fifteen minutes, during which thirty-two teeth, entire or fragmentary, have been removed. Guy has expressed the opinion that a reasonably expert dentist should be able ' to clear a mouth ' in four minutes. Of course some extractions are very easy and some very much the reverse, according to the number of teeth and the manner of their setting; but usually all that is needed can be done in ten minutes at the very outside, and the consumption of more time is undesirable and due to a bungling operator. Mr. Guy has sent out from the Edinburgh Dental School hundreds of dental surgeons who, by a special system of training which he has made peculiarly his own, are quick and expert operators, and in this, if for no other reason, he has earned the appreciation and gratitude of more than one anæsthetist.

CHAPTER VIII

THE USE OF LOCAL ANÆSTHESIA

At the present day a work of this character could not be considered complete without the use of local anæsthetics in dental surgery being considered pretty fully. For the last fifteen years this method has been in considerable favour for use in the extraction of one or more teeth—sometimes where quite a number are being extracted; we think with doubtful wisdom in such cases.

The tendency to use local anæsthetics has, indeed, at times been overdone both in dental and general surgery. Much literature on the subject has emanated from Paris, and the practice has at all times been more popular on the Continent than in this country.

Sauvez, of L'École Dentaire, Paris, has given the subject very great attention, and read a paper in 1908 at the International Congress of Dental Surgery at St. Louis, but he did not meet with an entirely encouraging reception. This

was in many ways to be expected in the land where general anæsthesia had its birth; but, apart from this, there seems no manner of doubt that Americans are by temperament in no way likely to be good subjects for local anæsthetics, and the same may be said of the large majority of the Anglo-Saxon race.

Best of all suited for local anæsthetics are the stolid, phlegmatic persons of any nationality and French hospital patients, with whom the repeated assurances of the surgeon concerned that they will feel '*no* pain' cannot be altogether without influence.

In our own country there are many types of patients for whom local anæsthesia is not to be recommended. Young children, particularly if they are by temperament nervous and excitable, are bad subjects for it at all times. Neurotic, hysterical women it is also quite hopeless to deal with in this way, *unless on their own urgent request and insistence*, when on occasion, whatever they actually have felt, they will assert that the operation has 'not hurt them in the very least, and that they were quite right to choose cocaine!' There are certain individuals who have a rooted objection to losing consciousness of their surroundings and giving themselves up to a general anæsthetic. For these, if there be no contra-indication,

and if there be good chance of the analgesia being reasonably efficient, a local anæsthetic is to some extent indicated. Further, there are other people who can *never* be thoroughly rendered anæsthetic by means of nitrous oxide, although they are rare, and if the extraction required be a simple one, local anæsthesia may be often used with advantage. There is scarcely a dental surgeon in practice who has not at one time or another been an enthusiastic advocate of local anæsthesia (which has invariably meant *cocaine* under its own or a proprietary name), but there are few who remain so for longer than a year or two. Doubtless there are fashions in dentistry and anæsthetics, as in other things, but failures to produce a satisfactory degree of analgesia, bad after-effects, such as tendency to syncope (which may come on after the patient has left the house), or sloughing of the gum in one or two cases, tend to restrict the use of cocaine and preparations containing it. The general tendency at the present day seems to be to use a solution of 1 per cent. strength, and this is what Sauvez himself employs. He (*though a cocaine enthusiast*) lays it down as a rule, however, that *if more than a cubic centimetre* (16 *mins. approx., such as an ordinary hypodermic syringe holds*) *even of this weak solution be used, the patient should be placed in the supine position,*

and should remain resting for a considerable time after the operation is completed.

Such precautions are by no means common among dental surgeons who use cocaine in this country, and this may account to some extent for the frequency of syncopic attacks in patients who have been treated with cocaine. The advocates of local anæsthesia are wont to minimize the risk of cocaine, while they exaggerate the dangers and disadvantages of general anæsthesia, more often from ignorance than not. Each has its place, doubtless, in general and dental surgery. There have been authorities who were as strenuous opponents of cocaine as others were advocates of it, and there is much to be said on both sides.

The Advantages of General Anæsthesia.

1. The anæsthesia is certain and can be guaranteed, while with local analgesics we can only say, at the best, it is *almost* certain.

2. The patient does not realize the effort which the operator puts forth on his jaw, nor feel the jar of the forceps.

3. Several different extractions can be carried out at the same time.

4. Certain authors say that the healing is

more rapid than when a local anæsthetic is employed, and we believe this to be generally the case.

Advantages of Local Anæsthesia.

1. The lower rate of mortality is one which cannot be gainsaid, if ordinary precautions be taken to see that not too strong solutions of cocaïne are employed.

2. There is no need for any assistants (or witnesses in the case of female patients). There is no need to hold the patient down, etc., for there is no period of excitement and struggling.

3. The analgesia lasts long enough to prevent the patient feeling the after-pain of the extraction to a great extent, although in some cases severe after-pain may be experienced.

4. There is no apparatus of a complicated nature to get ready, for the syringe is always ready, if only used once in 10,000 cases.

The two methods commonly employed to produce analgesia by local treatment are:

1. By the injection of drugs into the part.

2. By means of local application of very volatile substances to produce freezing of the part.

The Production of Local Anæsthesia by the Injection of Drugs.

The drugs most commonly used for the purpose at the present day are, in order of popularity, cocaine, eucaine, tropa-cocaine, acoïne, 'stovaine,' closely allied to cocaine, and novocain.

With any of these drugs (with the exception of stovaine) suprarenal extract may be employed to intensify and localize the action. By far the most largely used drug for local anæsthesia is cocaine. It spurted into fame at the moment of its discovery, and as rapidly got into disrepute. Again it got popular when it was found that accidents were uncommon, comparatively speaking, if weak solutions were employed and precautions taken. Periodically, new synthetic drugs have been placed on the market, and vaunted as having all the advantages of cocaine without its disadvantages, but each in turn has proved inferior, and at the present day, with its drawbacks fully known as they now are, cocaine undoubtedly holds the field as the best local anæsthetic we have. It seems likely that stovaine will go nearer to displacing it from its proud position than any other synthetic compound, but the clinical evidence at our disposal at the present moment is not sufficiently ample to enable us to speak definitely on this point.

Cocaine Hydrochlorate.—Cocaine is utilized for anæsthetic purposes chiefly in the form of the hydrochlorate. This alkaloid was first obtained from the leaves of *Erythroxylon Coca* by Gaedeke in the year 1860. It was first employed for surgical work by Keller, of Vienna, in 1884, and since that time has been of priceless value chiefly in ophthalmic surgery.

The salt is freely soluble in water, spirit, and glycerine. Solutions of it are apt to become cloudy from the growth of fungi, and to prevent this boric or salicylic acid is commonly added by chemists. It is always desirable, as far as possible, only to use freshly prepared solutions if the best results are to be obtained, and these should be boiled beforehand to render them sterile.

One of the most marked properties possessed by cocaine, apart from its anæsthetic properties, is its power of depressing the circulatory organs. Faintness is very readily induced in some people, even by very small doses; they become extremely pale, and their pulse is found to be weak and irregular, and even imperceptible at the wrist.

Symptoms pointing to the absorption of cocaine into the general circulation most commonly arise when the injection is made into a highly vascular part, or the needle has by accident punctured

a bloodvessel. Untoward symptoms may arise from an unnecessarily large dose, impurities in the solution, want of aseptic precautions, or from physical causes apart from the anæsthetic. The effect produced by any given dose, however, will vary greatly with the type of the patient on whom it is employed, the age of the patient, and the part treated. A great deal depends on the absorptive capacity of the mucous membrane, as influencing the actual amount of cocaine which gets into the circulation. The laryngeal mucous membrane will stand a strong solution of 10 per cent., or even 15 per cent., which for the nasal mucous membrane or urethra would be much too strong. The absorption of $\frac{1}{6}$ to $\frac{1}{4}$ of the grain drug will, in the large majority of patients, do no harm; 1 grain will often produce dangerous symptoms, while, on the other hand, we have known as much as 2 grains injected at once produce no unpleasant effect, the patient being a vigorous man. It is this very uncertainty of action as regards toxicity, however, that makes cocaine so dangerous, and a further difficulty is that the symptoms may be delayed for a considerable time, and only come on when the patient is on his way home.

The toxic symptoms are: Trembling in the limbs, especially the lower extremities; head-

ache, vertigo, pallor; a cold, moist skin; feeble, rapid pulse, which in grave cases becomes imperceptible; slow, shallow respirations; incoherence of speech, nausea, vomiting, unconsciousness, tremors, and other muscular spasms; epileptiform attacks, dilated and unequal pupils, and disturbance of the circulation, ending in dyspnœa and death by asphyxia.

The treatment consists in using every effort to stimulate and restore the circulation. The patient, if not already supine, should be immediately placed in this position, air freely admitted and some alcoholic stimulant quickly administered, or a drachm of ether injected subcutaneously. The patient should be warmly covered, and pulse and respiration carefully watched, artificial respiration being employed if necessary. A capsule of nitrite of amyl may be of service, and $\frac{1}{150}$ grain of atropine and 10 minims of tincture of strophanthus may be injected hypodermically.

The Use of Cocaine combined with Adrenalin. —As is generally known, liq. adrenalin possesses a strong local vaso-constrictor power, so much so that even after a simple swabbing with a solution of 1 : 1,000 it is possible to obtain in a few minutes a local ischæmia such that operations on the nasal cavities, so ready to bleed as a rule, have been

performed without the patient losing a drop of blood.

The advantage of using this substance along with cocaine is that, in addition to rendering the region to be anæsthetized bloodless, it enhances the local action of the cocaine while lessening constitutional effects. It is well known that cocaine acts harmfully on inflamed and congested tissues, and its action, when injected into tissues that are soft and spongy, is often unreliable. In such cases, by using adrenalin to produce temporary ischæmia, we obtain the best results. A suitable solution to employ is one of 1 per cent. cocaine with 5 per cent. adrenalin.* A certain disadvantage may be urged in the absence of bleeding after a tooth is extracted under this combination, for in many cases the slight bleeding which under ordinary conditions follows the extraction of a tooth may be considered rather an advantage, tending to lessen the congestion in an inflamed gum.

The following advantages may be claimed for this combination, however:

1. The gum is rendered quite blanched by the first injection.

2. There is no bleeding from the prick of the needle.

* 1 : 20,000.

3. There is no bleeding after the tooth is extracted, even in hæmophilics, which allows of clean operating and facilitates the removal of difficult roots.

4. Analgesia is practicable even in soft and inflamed tissues, and more durable and complete in healthy tissues.

5. There are no syncopal symptoms nor cerebral attacks as a sequel, but, on the contrary, the cardiac systole is more energetic, and the heart-sounds better defined.

In view both of the costliness and high toxicity of cocaine, from time to time attempts have been made to find some synthetic drug which would be a good substitute. Chief among those which have been introduced are tropa-cocaine and β-eucaine. These are very similar to one another and to cocaine.

EUCAINE has been extensively used in the place of cocaine, and the chief advantages claimed for it are the following:

1. It has only one-fourth the toxicity of cocaine.

2. Its exhibition is followed by no unpleasant or dangerous after-effect.

3. Its action is more constant and lasting than that of cocaine.

4. It does not decompose on boiling (which

cocaine sometimes does do), and so can be rendered permanently sterile in solution.

5. It costs only one-half of the price of cocaine.

On the other hand, eucaine is much less soluble than cocaine, requiring 20 parts of cold water to dissolve 1 part of eucaine and 10 parts of hot water. It is considerably more irritating to delicate membranes than cocaine—*e.g.*, the conjunctiva. It is slower in action than cocaine, and after injecting it for a dental extraction it is necessary to wait at least ten minutes in order to get the full analgesic effect; its tendency to cause irritation leads to hyperæmia of the tissues frequently, which may be embarrassing to the operator; but this drawback can, of course, be overcome by combining suprarenal extract with it. Further, some observers have stated that eucaine is less intense an analgesic than cocaine, and that the analgesia produced by it is shorter in duration; but, most important of all, they state that it is practically as dangerous as cocaine, and that its toxicity has been greatly underrated.

A sterile 2 per cent. solution may be prepared as follows: To 1 part of β-eucaine 49 parts of distilled water are added. Heat the mixture in a test-tube over a spirit-lamp until solution has taken place: then heat to boiling-point, covering the mouth of the test-tube with a piece of cotton-

wool. A thoroughly sterile solution is thus obtained.

Dose.—15 to 20 minims of a 2 per cent. solution is sufficient for the extraction of a single tooth.

Reclus has employed eucaine on over 4,000 occasions without any serious accident, but Sauvez regards it as equally dangerous with cocaine, and considerably inferior in analgesic power.

Eucaine may be, like cocaine, combined with liq. adrenalin. 'Eudrenin,' a preparation of Parke, Davis and Co., is of this nature, and is put up in convenient glass capsules, insuring sterility, etc.

TROPA-COCAINE.—Of tropa-cocaine most of the remarks which we have just made in regard to eucaine seem to be true. Sauvez considers it as inferior to cocaine, and equally toxic to all intents and purposes. Dorn has, however, used it on hundreds of occasions with good results. In no case did he observe the slightest toxic symptom, and neither excitement, dyspnœa, nor faintness was experienced. For the majority of cases he used a 3 to 4 per cent. solution, injecting from 10 to 30 minims in three to five punctures in the direction of the roots of the teeth. The analgesia obtained by means of it lasts about ten minutes.

STOVAINE is the proprietary name of chlor-

hydrate of β-amylene, which is a derivative of the tertiary series of amino-alcohols.

It was discovered recently by M. Fourneau, the superintendent of the laboratories of a firm of chemists in Paris.

Stovaine crystallizes in small, brilliant scales which are readily soluble in water, methyl alcohol and acetic ether. It is less soluble in alcohol It is slightly acid in reaction.

Aqueous solutions of it can be sterilized by prolonged boiling, showing that stovaine is equal, at least in stability, to cocaine.

As regards toxicity, stovaine has only about one-third the toxicity of cocaine. It possesses a fleeting vaso-dilator action compared with the markedly vaso-constrictor action of cocaine, and, in addition, possesses (according to Pouchet) a tonic action on the heart. It appears also to possess some antiseptic and germicidal properties. In contra-distinction to cocaine, it may be given to patients in the sitting position, and after the operation is completed there is no danger in letting the patient leave the house and go home—no risk of syncope, in short.

The strength of the solution should be 3 to 4 per cent., in distilled water.

Novocain.

Novocain has been used as a substitute for cocaine, and improvement on eucaine and stovaine, of late, with such favourable results, that it is worthy of some notice. Novocain is the hydro-chloride of para-amido-benzoyl-diethyl-amino-ethanol, represented by the formula—

$$NH_2C_6H_4COOC_2H_4N(C_2H_5)HCl.$$

It possesses a double claim to consideration as a local anæsthetic, being constituted both as an amino-alcohol and as an ester of para-amido-benzoic acid, each of which classes of chemical substances possess valuable anæsthetic properties. Novocain completely fulfils the highest standard of the requirements for an ideal local anæsthetic:

1. Ready solubility in water. The solutions are stabile, sterilizable by heat, and capable of rapidly penetrating the tissues.

2. They possess a low degree of toxicity in proportion to their anæsthetic power.

3. Absolute freedom from irritant action.

4. Physiological compatibility with adrenalin preparations.

In regard to the last two points, novocain is the only local anæsthetic which possesses these qualities.

Novocain may be heated to 120° C. without

decomposition, and melts at 155° C. It is soluble in its own weight of water—cold—and the solution is neutral in character, and may be repeatedly boiled without decomposition. A 5 per cent. aqueous solution is isotonic with human tissue fluids, and the osmotic tension is equal to that of cocaine solutions of the same strength.

Physiological Characters.—Braun considers this drug as an anæsthetic with an ideal absence of irritating properties, and, by the experimental investigations on animals and abundant clinical experience, has confirmed his views. The anæsthetic potency of novocain is much enhanced when it is combined with adrenalin. It is ten times less toxic to mankind than cocaine, and it is, further, free from any local irritating properties.

There is therefore no sloughing or ulceration, nor any signs of inflammation, produced at the site of the injection: a most important—indeed, essential—matter in dental work.

For dental anæsthesia a 1 or 2 per cent. solution of novocain with suprarenin borate is employed. Up to 4 per cent. solution without suprarenin borate are used at times with excellent results.

With this drug, as with others, the use of a suitable syringe is most important, in order that sufficient pressure may be got up to force the

fluid far into the tissues. Several instrument manufacturers make excellent all-metal syringes for this purpose.

It is no more effectual than other drugs where the periodontal membrane is acutely inflamed, and the best results are always obtained, of course, with subjects who are self-possessed and possessed of common sense. Ten to fifteen minims of an 8 per cent. solution is sufficient to anæsthetize a single tooth.

Technique of Local Anæsthesia by Infiltration.

The syringe for making injections into the gums requires to be somewhat differently and more strongly constructed than the ordinary hypodermic syringe, for the tissue into which the injection is made is very dense, and offers a considerable degree of resistance. The syringe which Sauvez recommends is that of Pravatz.

The armature of this syringe is fitted with two wings, which act as a *point d'appui* or fulcrum for the middle and index finger, so that greater purchase is afforded to the thumb, which presses on the end of the piston. The surface of the head of the piston is concave and solid, allowing considerable pressure to be applied by means of the thumb or palm of the hand. The needles are

screwed on, and not simply slipped on (as in some syringes); for in such a union, if much pressure be exercised, the fluid is allowed to escape. Each needle should also be fitted with a leather washer, so that, if the butt is firmly screwed against this washer, it is practically impossible for any fluid to escape.

The glass barrel of the syringe is, moreover, partially surrounded by metal, which adds to the

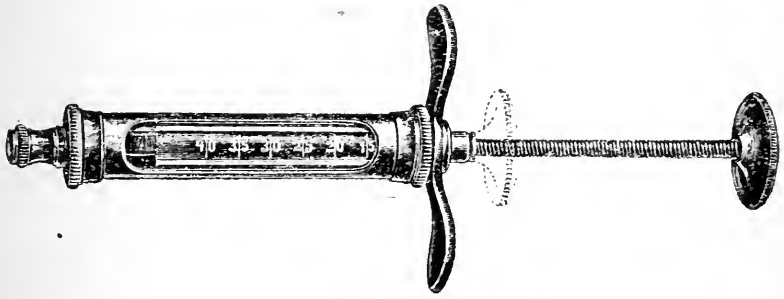

FIG. 20. — SYRINGE WITH EXTENDING PISTON-ROD.
(Model similar to Pravatz.) Reduced to ½ size.

strength of the syringe, while the rod of the piston is graduated in fractions of cubic centimetres, so that by means of a sliding screw-nut the contents of the syringe may be divided into as many parts as one wishes. As regards needles, those made of platinum-iridium have some advantages, and can be made red-hot to sterilize them if necessary. But they have the disadvantage of being rather too thick and not penetrating

the dense tissues easily, while the thin ones are too fragile to offer sufficient resistance without breaking. Sauvez only uses steel needles (as regards his own practice), and finds that, although they also break easily, they are preferable in the end, on account of the small size of the puncture, and of the ease with which they penetrate the tissues. They have the drawback, however, of requiring to be changed too often. In addition to the *straight* needles which one uses most often, we have also found very useful both the curved ones and those in the form of a bayonet; but these last are very readily blocked up. Before fitting a needle on to the syringe it is necessary to see if it is quite clear or not, and in order to be sure of this it is usual to keep a thin metal wire in the lumen of it when the needle is not in use.* One should be quite sure that the needle is sharp, and that the sides are not roughened with rust, which would render the penetration of the tissues more slow and painful. Platinum-iridium needles have the disadvantage of blunting easily and the point becoming turned back, and this is all the more likely to happen when the tissues are dense and tough.

The syringe should only be used for cocaine,

* It is best to use Schimmel's needles with the shaft and hilt in two pieces, and use a fresh shaft for each patient.

and another should be kept for exploratory purposes and for the injection of other drugs, such as ether or caffeine.

The Sterilization of the Instrument.

Antiseptic precautions are not the less necessary as regards the syringe than the fluid to be injected. Neglect of proper precautions to secure complete asepsis may have occasionally the most serious consequences. It is more than probable that many ill-effects of the injections, such as delay in healing, unhealthy condition of the wound, shedding of splinters, wound infection, and sloughing, which are laid to the score of cocaine, are only due in reality to neglect of these preliminary precautions. In short, it is only too easy to inoculate a wound with septic material which remains on the needle from a previous operation. The asepticity of the instrument should be secured in the following manner:

When the operation is completed, the syringe is placed in a glass beaker containing a 5 per cent. solution of carbolic acid; the b rrel is filled with this solution, and allowed to remain so for the time it is not in use. A rigorous asepsis is thus secured, and, in addition, the packing of the piston being always immersed in fluid remains moist and swollen, and so does not allow leakage alongside

it when in actual use. As regards the needles, in addition to putting them through a flame, it is well to boil them for a little in a capsule over a spirit-lamp, having put a little boracic acid into the capsule.

Precautions to be observed before making the Injection.

Before making the injection we should get the patient to rinse his mouth out with boracic lotion, a saturated solution, or even a solution of 1 : 1,000 formalin. A piece of cotton-wool dipped in alcohol and 1 : 1,000 sublimate is then passed over the gum in order to disinfect the region, which is then dried with a piece of anhydrous aseptic wool. These preliminary precautions must not be neglected; they are simple, and do not really occasion loss of time, and, if one carries them out always, the risk of any infection in the site of the injection may be practically done away with.

The Injection.

In the vast majority of cases one can say that the actual prick of the needle is quite painless, particularly when one uses very fine and sharp needles. Nevertheless, the puncture may be painful enough at times, even though the gum be

not actually inflamed—that is to say, although there be no periostitis or gingivitis.

The patient sometimes dreads this prick, and starts violently when it is made. It can be rendered absolutely without pain by the following means: (1) If the tooth is sensitive to cold from caries or from the pulp being laid bare, or if there be a neighbouring tooth similarly sensitive to cold, a small lump of cotton-wool soaked in 5 to 10 per cent. solution of cocaine should be applied to the gum for a minute or two. (2) If, however, the tooth to be extracted is not actually sensitive to cold, we can effect the same by means of a spray of chloride of ethyl. The needle may be safely put in at the moment the gum gets blanched and frozen.

This method is more rapid than the first-named; in addition, it restricts the circulation of the cocaine to the immediate locality, and so renders its action the more efficacious.

In order to know where exactly to put in the needle and make the injection efficaciously, one should know something of the tissues which are being traversed.

We will therefore briefly describe the mucous membrane covering the gums. It varies considerably according to the region we are examining. Speaking generally, it is intimately united to the

periosteum of the jaw in the region of the alveolar portion of the teeth, and it is there difficult to separate it from the jaw; it thus belongs to the fibro-mucosæ, and, as regards its character, is thick, hard, resistant, and non-vascular. In the region of the base of the alveoli the periosteum of the jaw supplies a prolongation to each alveolus, which adheres by one of its surfaces to the sides of the cavity, and by the other to the tooth itself. On the other hand, equally at the base of the alveolus, the mucous membrane is thickened, embraces the neck of the tooth, and thus meets with a part of the crown, forming around it a ring or even a cylinder 3 millimetres deep, remarkable for its thickness, in consistence very like fibro-cartilage, and very often inflamed.

The reader will do well to refer to some treatise on anatomy in order to render himself quite familiar with the arrangement of the tissues in this region. At the palatine arch the mucous membrane is still more united in its thickness to the periosteum, and this union is so deep and complete that to separate one from the other by a dissection is practically impossible. We know that the gum is reflected on to the inside of the cheeks and lips, forming with them a cul-de-sac which limits above and below the vestibule of the mouth. In this region the mucous membrane

consequently leaves the periosteum, and one finds a layer of tissue which infiltrates very easily and increases in thickness the farther we get away from the actual alveolar portion. Consequently, if an injection is to be efficacious it must be made at a point where the mucous membrane and the periosteum are intimately united, and therefore not too near the neck on the one hand, nor above or too near the cul-de-sac between the gums and lips or cheeks.

At the moment of making the injection the syringe is held in the hand like a pen, so that a point of support may be obtained on the jaw with the middle, annular, and little fingers.

Sauvez directs that the needle be inserted into the mucous membrane at a point situated as nearly as possible midway between the free border of the gum and the spot where the root of the tooth should be found, rather nearer the neck of the tooth, and be pushed in obliquely. The puncture should not be deep, and should be made, not *hypo*dermically but *en*dermically; indeed, the expression 'hypodermic' should not be used in connection with it. The piston of the syringe is then pushed home very gently and without any jerks, and always very slowly, in order that time may be allowed for the fluid which is injected to dissipate itself in the meshes of the tissue. A

good deal of resistance should be experienced in the tissues also, this being sometimes very great. The needle is thrust in little by little, keeping it always in the thickness of the skin. If the injection is made in this way, one sees, as the piston is gradually pushed home, the mucous membrane become white and blanched over a certain area, and the centre of this zone may be represented by the point where the needle was thrust in. Two errors must be avoided, however: one is not to put the needle in far enough, and the other to put it in too much. If one does not put it in far enough, the mucous membrane is seen to be raised at this point, but not in its whole thickness; it forms a cyst or 'bleb' just like that which is caused by a slight burn on the skin. It is nearly transparent and clearly defined. If the piston is still thrust home, the blister bursts and the liquid escapes. If the needle be withdrawn and a finger-tip be placed over the puncture to stop the fluid from escaping, the anæsthesia is sufficient. In certain regions, especially in the neighbourhood of the first molar tooth, injections are difficult to make in a satisfactory manner. At this point the fibro-mucosa is very thin, whilst the mucous membrane, abandoning the periosteum, leaves between them a layer of uniting tissue which is very readily infiltrated, the more so as

the last fibres of the buccinator muscles lose themselves there.

If one buries the needle too deeply or too perpendicularly, it strikes against the bone, and one has to withdraw it with the point gone, no fluid frequently having permeated. One may be tolerably certain that the anæsthesia will be efficient if the piston is hard to press home. At times one is inclined to think that the needle of the syringe is blocked, so much pressure on the piston is needed to force in a very small amount of the fluid. If one feels the liquid going in without any effort, the best way is to withdraw the needle and make a fresh puncture, for this indicates that the needle is not properly thrust into the gum, or that there has been a leakage of the liquid at the point where the needle is screwed on to the syringe.

The Number of Punctures.

As to the number of punctures one should make, it is very difficult to give any precise directions, but one must act differently according to each case. The only principle which one can formulate is that it is necessary, as far as possible, to surround each tooth with a zone of anæsthesia, which will necessitate multiple punctures. When the teeth are close together, one need only make

injections on the inner and outer sides of the alveolus. Generally speaking, in this case it is most often necessary to make several punctures on each side. They are, indeed, quite sufficient when made into a healthy mucous membrane, thick and resistant. But the majority of the teeth which are extracted are associated with inflammatory conditions, which, if they are not acute at the moment of extraction, have, at any rate, left the mucous membrane more or less affected. Further, if the injection is to be made in a soft tissue, flabby, fungous, and infiltrated, it will be necessary to make several punctures. One is struck by the fact that a single injection of $\frac{1}{3}$ centigramme in the palatine region is quite enough to secure a good analgesia, because the tissues covering the bony arch are very dense, while on the external alveolar side several punctures are sometimes necessary. If the neighbouring teeth are gone, or if only one is gone, the needle is inserted where the tooth was, care being taken to make the puncture perpendicular to the jaw, but in a plane parallel with the mucous membrane. Further, in the case of a tooth which is isolated on all sides, one should put the needle in on each aspect of the tooth if it is to be extracted. Although such a custom is common, it is not necessary to place the tip of the finger on the

puncture to prevent the fluid escaping, except in the case we have just mentioned. Indeed, this precaution is useless in the large majority of cases, for the fluid only tends to come back when difficulty has been experienced in introducing it. It only escapes when it has not penetrated to the true mucous lining, and especially when a blister has formed. In such cases, when one withdraws the needle, the liquid escapes by the little orifice just as it does when one punctures the cyst with a needle.

Some people recommend that the finger should be placed on the point about which the puncture has been made, not only after injecting, but even at the moment when one makes the injection, in order that one may feel the mucous membrane being raised, and be sure that the injection has penetrated into the tissues. This is not necessary, however, for the bleaching of the gum is a sure sign that the injection has been properly made. On the other hand, it is very often difficult to stretch out the cheeks and push back the tongue with the mirror. This has to be done when the injection is made on the external alveolar border which corresponds to the second and third upper molar, and the part of the alveolar margin which corresponds to the large lower molars. On the upper jaw one is embarrassed by the cheek, and

on the lower by the tongue, so that this use of the finger is not advantageous.

If two injections only are made—one on the inner, and the other on the outer side—there is a practical point of some moment which may be mentioned. The needle is thrust into the tissue, its point turned towards the periosteum; the injection is then made so as to get a blanched area, and then, giving the syringe half a turn forwards, the injection is continued. In this way a semicircle of anæmic tissue is obtained, which is superimposed on the first. The syringe is then given a complete turn, so that the side which looks forward is turned backwards, and the injection is made anew. A third zone of blanched tissue is formed, which is partly perimposed on the first. We have thus several ischæmic zones superimposed exactly in the region where the analgesia should be most complete.

Although one is obliged to employ several punctures to get the proper amount of analgesia, they should nevertheless be reduced to a minimum. The place at which they are made becomes rapidly covered with blood from slight hæmorrhage, which it may, however, be difficult or tedious to arrest. It will be found, as a general rule, that four or five punctures will suffice, with the use of 1 centigramme of cocaine, to induce a

proper degree of analgesia. The injection having been made, the question then arises, '*How long should one wait before proceeding with the extraction?*' It is a common custom to wait five minutes for the cocaine to act, but this is scarcely necessary, in view of the fact that, when the injections are properly made, some little time is taken up in that way. If one makes several injections on the inner and outer side of the tooth in fractional doses, even if the extraction is commenced two minutes after the last injection, an interval of probably not less than five minutes exists between the first injection and the commencement of the operation.

As a matter of fact, it is better not to wait so long as five minutes, for during the period of waiting the patient is a prey to certain apprehensions and misgivings, in spite of all that can be said to reassure him.

During the period of suspense it is a good plan to chat to the patients, in order to keep their mind occupied and so avoid this pre-operative anxiety. They may be shown that they no longer feel the prick of the needle, and this often produces on them an excellent moral effect. They may be told also to keep rinsing out the mouth with boric lotion or some other antiseptic. Cases in which analgesia is slow in appearance are very rare,

but one comes across patients in whom cocaine analgesia is produced more slowly than with others.

Such are the indications which appear most rational in all the cases where there is a healthy mucous membrane, and where the puncture is to be made in an easily accessible region. These cases form, fortunately, the majority of those with which we have to deal; but at the same time there are some cases which we come across where circumstances render the production of analgesia less easy, and certain modifications in our methods are required.

Difficult Cases.

We will now deal with these, and in such a manner as to complete our description of the technique.

If the gum is soft or stripped from the alveolus, it is difficult to get good results. One of the finest of needles must be used, in order that traumatism may be reduced to a minimum and bleeding be avoided, and the fluid should be injected as slowly as is possible. One can attain this by means of a small, movable screw-nut on the piston-rod of the syringe.

Inflammation of the gum is frequently caused by the presence of tartar, and it is in the regions

where this is found that we find the puncture difficult to make. We know that tartar is found for the most part in the places where mastication is carried on only very little or not at all, at the back of the teeth, which are badly cleaned by the tongue—that is to say, on the external facets of the teeth in general, and more particularly those which are near the secretory orifices of the salivary glands (the external facet of the large upper molars, of the incisors and lower canines).

The result is that an injection is difficult to make on the external alveolar border of teeth in general, and in the region of the inner alveolar border of incisors and inferior canines. Very rarely is it necessary for us to extract the latter; they are, as we know, the teeth which have the least tendency to caries. They disappear almost always only at an advanced age, when the rarefaction of the alveolar process makes them loose. Their removal is then a painless matter, and therefore we need not consider them further.

For injections on the internal alveolar border, as the gum is often thick and soft here, one should not make the puncture far from the actual border in the region of the neck of the tooth, as it will often happen that here will be found the true mucous membrane.

One should always avoid making the puncture in the cul-de-sac which is formed by the cheek and the gum; in this region the mucous membrane is separated from the periosteum by a loose layer of cellular tissue, which is very readily infiltrated, as we have previously remarked; and one can only find the true dermal layer with a great amount of trouble. Besides, we have seen that for the puncture of the inner side of the gum, where the mucous membrane is healthy most often, one need only use one-third of the syringeful, and keep the remaining two-thirds for the outer side. These punctures, made a little distance from the neck, ought to be carried out in the direction of the nerves which supply the tooth which we are to extract.

In all cases where we are confronted with a soft and spongy gum, we ought not to pretend that we can produce a complete anæsthesia by the use of cocaine alone, but we ought to try to get the maximum effect possible; and this can only be got by the use of the combined cocaine and adrenalin method. Even with cocaine alone, however, we can produce a great diminution of the pain, and we can obtain an absolute insensitiveness if we combine the injection of cocaine with the use of ' coryl ' as a freezing agent.

When, however, there is periostitis and, above

all, *acute* periostitis, as the gum is often hyperæmic and inflamed, especially on the outer side, we should carry out the injection in the manner we have described, slowly and carefully, so as not to lose any of the liquid, and always keeping the needle in the dermal layer. In this case cocaine is alone employed, and is preferable, for the pain persists after the extraction; and as the analgesia produced by cocaine lasts ten to fifteen minutes, the painful sensation is lessened, while the effect produced by freezing passes off in a few seconds.

If an abscess exists in the region of the tooth, and a collection of pus has already distinctly formed, it is necessary to take certain precautions in making the puncture, and for two reasons: not only is the puncture itself very painful, but, if badly made, it does not produce analgesia. The chief precaution to take is not to penetrate the pouch of pus; a hypertension of the liquid matter contained in the pouch is produced if this be done, causing intense pain. The puncture ought therefore to be made in the side of the abscess. This may seem at first sight difficult to carry out, but experience shows that it is very easy. If one sees that the needle has penetrated the abscess cavity by mistake, it should be withdrawn and a fresh puncture made. Sauvez suggests that in such cases the puncture be made at a certain distance

from the point where the mucous membrane has been raised by the abscess, just as in the case where the periosteum brings about the formation of a red band where the mucous membrane is inflamed; it is proper to make the puncture where the tissues are just healthy, and later one can deal with the affected area.

When a fistula exists opening on the gum in the vicinity of a tooth which one wishes to extract, one finds often that the fluid runs out through the fistular orifice as it is injected. The emission of this fluid indicates that the needle has passed between the bone and the gum, and, as in the neighbourhood of a fistulous orifice the fibro-mucosa is often detached and stripped from the bone, the liquid under pressure passes along the side and comes out of the fistulous opening at once, without having produced any analgesic effect. It is necessary to withdraw the needle and insert it more deeply. One will be certain to be into the true derma when a resistance to the injection is experienced, and the fluid no longer tends to escape by the fistulous orifice. We have just passed in review the different cases where an inflammatory process of some sort has caused a modification in the paradental tissues; in other cases the difficulties are in connection with the situation of the tooth.

The greatest difficulties with which one is confronted are those which arise when it is necessary to make the puncture in the vicinity of the external alveolar border of the upper molars, or to render analgesic the tissues surrounding the second and third lower molars.

When one is desirous of making an injection into the vicinity of the second or third upper molar on the external side, it is necessary to tell the patient *not* to open his mouth too widely, because by doing so he will cause a contraction of the buccinator muscle, which would come into contact with the outer alveolar borders, and so occlude the field to be treated. The patient should be asked only to open the mouth moderately wide, and one is then enabled to place a mirror into the space between the gum and the cheek which covers the alveolar border; this mirror will push out the cheek, and at the same time lay bare the region which one wishes to puncture. It is preferable in this particular case to make use of a curved needle, which allows of one seeing the point of the needle in the mirror so that it may be directed at will.

We are of the opinion that it is better to operate thus than to place on the gum a finger, which is by no means always aseptic, in order to feel the mucous membrane rising. The diagram below

shows better than a prolonged description the difficulties which one meets with when injecting one of the two lower molars at the back, or wisdom teeth. The vertical section which we give is made between the second and third lower molars. Besides, in operating on the floor of the mouth it is difficult to see properly, and the contact of the mirror with the tongue or cheek

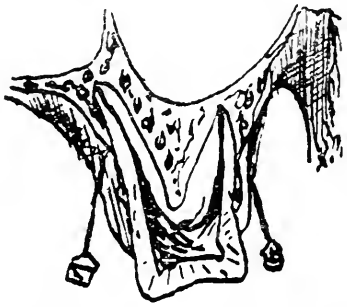

FIG. 21.—SECOND OR THIRD UPPER MOLAR.
(Vertical section.)

causes in certain subjects a reflex nausea or retching, which is very annoying to the operator.

When one has made the puncture, one finds that the needle almost at once comes into contact with the alveolus, whence it follows that one ought to make the injection in a direction parallel with the mucous membrane, which one can best do with a curved needle. On the inside, on the contrary, there exists a considerable depression limited above by the posterior part of the stylo-

hyoid ligament. There, again, it is unnecessary to make a deep injection; it is only necessary to put the needle in for 2 or 3 centimetres at most. If one makes the injection lower, the needle passes through the mucous membrane which covers the osseous crest, and comes out below this crest all the more easily, as the mucous membrane is thin

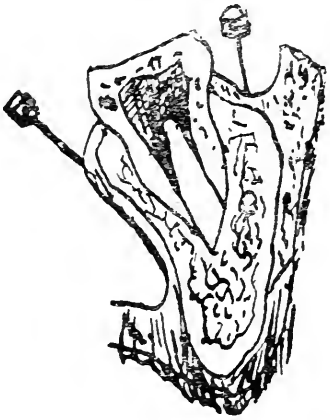

FIG. 22.—SECOND OR THIRD LOWER MOLAR.
(Vertical section.)

on this region. These precautions are the more necessary to render the extraction of the last two molars painless, as these are firmly held in their sockets, and as in cases where the fluid does not penetrate into the tissues it is spread over the mouth, sometimes even to the vicinity of the pharynx, where the bitter taste which it possesses is much objected to by the patient.

One c.c. of a 1 per cent. cocaine solution, freshly prepared in distilled water, seems to us sufficient and necessary for dealing with the large majority of cases, and to avoid accidents. The horizontal position is absolutely necessary if one injects more than 1 c.c. of cocaine.

Before or after the operation the patient should be given a liquid stimulant of some sort, or something to eat, and be laid in the horizontal position for a quarter of an hour at least, if only 1 centigramme of cocaine has been injected, and for even two or three hours if the dose exceeds a centigramme (Sauvez).

Local Anæsthesia by the Use of Refrigerating Agents.

The freezing agents used for this purpose are methyl and ethyl chloride, and various proprietary preparations of the two latter containing varying proportions of them, such as coryl* and anestile (Bengue).

Ether is seldom if ever used nowadays for local analgesia in the mouth, as it is less pleasant and less efficacious than a mixture of ethyl and methyl chloride, though these are now rarely used.

* Coryl is ethyl chloride mixed in such proportions as to have a boiling-point of 0° C. 'Anestile' consists of ethyl chloride 5 parts, methyl chloride 1 part.

Chloride of Methyl is a colourless gas at all ordinary temperatures with an ethereal odour, very soluble in alcohol, and somewhat soluble in water. It requires to be kept in strong metal cylinders capable of sustaining a heavy pressure. Owing to the difficulties of storage, from extreme volatility and the extremely intense cold which it produces, methyl chloride is not commonly used alone, at any rate, in dental surgery. By directing a stream of methyl chloride on to any tissue, a lowering of temperature as great as 50° to 60° C. below zero is produced very rapidly, with complete refrigeration. The degree of refrigeration is very difficult to regulate, and may be so severe as to cause complete disorganization of the tissue or even the formation of a complete eschar. Fortunately, methods have been devised which overcome, to a great extent, this drawback of methyl chloride. The drug is put into a glass vessel specially made for the purpose, known as a thermo-isolater, because it prevents the access of warmth and lessens the evaporation of the liquid. With the methyl chloride a small quantity of ether is mixed, and the mixture thus formed is applied to the inside and outside of the gum by means of tampons of cotton-wool covered with a fine net of silk and carried on a wooden handle. The tampon is dipped into the methyl chloride

mixture, and, after being fairly saturated, is applied for one or two minutes to the surface of the gum. On removing it, if the proper degree of freezing be produced, a white patch will have formed on the mucous membrane, and the surface of the gum will be quite insensitive. Even with these precautions, however, it is difficult to exactly graduate the refrigeration and to localize it.

Chloride of Ethyl.—The chloride of ethyl used for local anæsthesia is identical chemically with the drug which is now utilized for inhalation purposes, although the latter is somewhat more carefully prepared. It was employed for local anæsthesia as far back as 1866 by Rottenstein; later on Redard drew attention to its value, and in 1891 Meng employed it for local analgesia at the Paris Dental School. It was all the more readily taken to at this time owing to the bad repute of cocaine, in connection with which so many accidents had happened.

Owing to the extreme volatility of the drug, it requires to be very carefully put up. It is usually dispensed in small glass cylinders containing from 30 to 60 c.c., with a capillary tube opening at one or both ends, and a metal screw-stopper with a small washer of cork or metal. If there are openings at both ends the tube can be refilled. The capillary tube for exit is extremely fine, and there

is no known filament which can be passed through it. It is about $\frac{1}{25000}$ inch in diameter.

The cylinders are very fragile, and very apt to be broken or to burst in hot water. Metal cylinders are also used and are in some ways preferable.

Method of Application: The surface of the gums is dried with a piece of cotton-wool, and a piece of cotton-wool is arranged in the mouth so as to prevent the ethyl chloride stream being projected against the fauces. The cylinder is held in the palm of the hand, and with the nozzle directed downwards; the stopper having been removed, the jet is first directed against the napkin or bib on the patient's chest, and then rapidly turned upwards towards the region of the gum which one wishes to freeze, holding it about 10 to 12 inches from the patient's face. In this way one avoids the risk of directing it into the eye of the patient, which, though harmless, is painful for the patient.

It is important not to hold the flask too near the patient's face, as if this is done the ethyl chloride reaches the gum, not in the form of a spray, but in a steady stream, and is wasted, while analgesia is slowly produced, and is evanescent in character.

As the hand of the operator may be, or becomes, shaky, it is well to have some sort of support on

which to steady it. When the gum on one side has become white and frozen, attention may be directed to the other side, care being taken to occasionally direct the spray against the frozen side, in order that it may not become thawed before the other is ready. Complete freezing having been obtained, the flask is quickly laid down or handed to an assistant, and the operation proceeded with.

When one is accustomed to using ethyl chloride as a refrigerating agent, and if care be taken to wait sufficiently long for proper freezing to take place, it is found that by means of it the pain occasioned by the extraction of a tooth is greatly diminished. Its use is, however, practically restricted to the anterior part of the mouth, and back teeth are not suitable. Moreover, it is practically impossible to prevent some of the drug from flowing over into the mouth and mixing with the saliva, which some patients will object to considerably. It is, of course, useless and strongly contra-indicated in acutely inflamed teeth, where the access of cold causes much pain to the patient. It is most useful for cases in which a number of loose and fragmentary roots have to be removed, especially in timorous patients.

Indications and Contra-indications for Refrigeration and Cocaine Anæsthesia.

Freezing agents are better not used in the following cases also:

1. When the patient cannot breathe, except with difficulty, through the nose.

2. When the patient is a young child or a very nervous, timid person, for with such people the sight of the apparatus, the sensation of great cold, and the smell and taste of the drug in the mouth cause alarm and restiveness, and sufficient time is not allowed to produce proper freezing.

3. If the pulp of a tooth is sensitive to cold, or if the tooth to be removed is close to another with a sensitive pulp. Moreover, if the pulp is sensitive, there is neither advanced caries, abscess, nor fistula, and cocaine will act particularly well in such a case. In hospital practice, of course, teeth with the pulp laid bare are frequently extracted, but such cases are less common among private patients, and should be increasingly so.

4. When the pain produced by the extraction may last a long time, as in a case of acute periodontitis, an extensive extraction, or the removal of a large molar with separate roots. Here the action of a freezing agent would be too brief, and cocaine would be more satisfactory.

5. When the tooth to be removed is a second or third molar, with an operator not thoroughly familiar with the use of coryl, etc., and a nervous patient, who has not sufficient self-control to abstain from movements of deglutition, etc., in consequence of the irritation set up by the drug used for spraying.

Freezing agents are specially contra-indicated for the extraction of the lower molars, especially when the patient has a tendency to the excessive secretion of saliva.

6. When the actual cautery is to be used.

Cocaine is contra-indicated—

1. In patients afflicted with cardiac affections, with aortic disease especially, and those with a weak myocardium.

2. In neurasthenic patients.

3. In anæmic and debilitated people.

4. In those affected with acute or chronic disease of the lungs and organs of respiration.

5. In the obese and women who are suckling.

Refrigerating agents may take the place of cocaine in the following cases—

1. The injection of cocaine is difficult to make when the gums of the patient are soft and fungating. Now, it is especially this condition of the gums which one meets with on the external alveolar border, and this is the most suitable region for the application of freezing agents.

2. When an abscess has formed in connection with a tooth, it is usually due to the presence of advanced caries of the fourth degree, and consequently the pulp does not exist any longer, and any sensibility to cold has completely disappeared; in such a case a refrigerating agent such as coryl may be used with advantage, more especially as the abscess is formed almost always (except in the lateral incisors of the upper jaw) on the outside of the alveolar border, and causes the mucous membrane to bulge just at the point where it is easiest to produce freezing. The same remarks apply to fistulæ, which are almost invariably due to the pre-existence of an abscess.

3. As regards the position of the tooth to be extracted, difficulties will have to be encountered whatever method of local anæsthesia be employed.

CHAPTER IX

THE ACCIDENTS OF ANÆSTHESIA

THE two chief troubles involving anxiety to the dentist and anæsthetist and risk to the life of the patient during anæsthetic work are—(1) Syncope; (2) Asphyxia.

The *Symptoms* of syncope may be summarized as follows: Sudden dilatation of the pupil, extreme pallor, muscular relaxation, failure of the pulse, and shallow breathing.

Treatment.—Prone position, tongue traction, artificial respiration, lip rubbing, hypodermic of pituitrin or strychnine, or a hot saline enema.

Signs and Symptoms of asphyxia may be summarized as follows: Increasing duskiness of complexion, violent respiratory efforts, and gradual pulse failure.

Treatment.—Removal of foreign bodies, mucus, or blood, from air-way, tongue traction, compression of the chest or artificial respiration (Sylvester's or Schäfer's method), and if need be laryngotomy.

Syncope.

If the lines of practice laid down in this work be followed, and the use of chloroform avoided altogether, if possible, and that of ethyl chloride made with discretion and skill, cases of syncope must be very rare indeed. Still, every dental surgeon should know how to deal with the condition if it arises—and it may arise at any time. Patients have died from syncope in a barber's chair, and may do so in a dentist's with no ancillary aid from anæsthetics.

Cases of fatty heart have to be borne in mind, but let not every person who is obese be regarded as a subject of this grave disorder.

Another condition which may call for care and give rise to grave anxiety is what is known as the *status lymphaticus*—too often only 'diagnosed' at the post-mortem. The patients are often the victims of considerable overdevelopment of adenoid tissue, involving enlarged tonsils and adenoid growths in the naso-pharynx. They are usually mouth-breathers, highly nervous, with a quick, soft pulse.

A dental surgeon cannot be expected to take in all these things, and a few others, at a glance, but it is as well as a matter of practice for him to take stock of the patient's physical condition

before entering into the question of anæsthesia, and if necessary call in the assistance of a medical colleague or anæsthetist.

As regards symptoms and signs, they are summarized above, and very little more need be said about them. Most people are familiar with the appearance of a person who has fainted. There is the same feeble, fluttering pulse, great pallor, relaxed extremities, dilated pupils, cold, clammy perspiration, and feeble, shallow respirations, which sometimes die away completely. The signs and symptoms of ordinary fainting and a severe syncopic attack vary but in degree, and the former may readily pass into the latter. If the attack come on during the course of a nitrous oxide or gas and ether anæsthesia, the change in the facial colour is not so great, nor has it so much the ashy hue of death, owing to pre-existing lividity. The alteration in the nature of the respirations is very marked, for from being quick, noisy, or even stertorous, they suddenly disappear or become very shallow in character. In the anæsthesia of chloroform syncope may occur with lightning rapidity, and the pupils dilate and respiration and pulse cease practically simultaneously.

Treatment.—The cessation of breathing for longer than a few seconds often responds to the

simple pressure of the hand on the chest wall. If this is not immediately successful, however and symptoms of cardiac failure are also noticed, prompt measures are essential in order to prevent a fatal syncope, and the success following them will depend largely on the vigour and rapidity with which they are carried out.

The patient should be instantly placed on his back, with the head lower than the body and hanging over the end of a couch or table or extended dental chair. The mouth should be opened, tongue drawn well forward with a forceps, and the chest rhythmically compressed.

Fresh air should be freely admitted by the doors and windows.

A capsule of amyl nitrite should be cracked and held to the patient's nostrils, or a little strong ammonia similarly applied on a glass stopper.

All clothing hampering the chest and abdomen should be rapidly removed, and the face and chest wall smartly slapped with a wet towel or napkin.

In the very large majority of cases, fortunately, the above treatment, properly carried out, will suffice to restore pulse and breathing. The patient will then simply require to be kept warm and be supplied with plenty of fresh air.

If these efforts are unavailing, however, you must by no means be discouraged, but immedi-

ately resort to efficient and, if needed, prolonged artificial respiration.

Sylvester's Method.—The patient lying supine on the floor or on a table, a pillow or folded coat should be slipped beneath the shoulders, so that the head hangs down and the neck is extended.

The tongue must be kept well drawn forward the whole time. This may be effected with a simple rubber band over the tongue and under the lower jaw, or by means of an assistant with tongue forceps.

The operator should stand behind the patient, grasp the arms about midway between the shoulders and elbows, and press them firmly into the sides of the thorax, rotating them at the same time outwards. Maintain this position for a couple of seconds, while the assistant forces the diaphragm upwards by pressure on the abdomen the while; then steadily draw the arms upwards and outwards until they meet above the head of the patient, at the same time slightly lifting him from the ground, the assistant at this point releasing the pressure on the abdomen. The downward movement is then repeated, and this is kept up at the rate of sixteen to the minute, care being taken not to overdo the pace.

Hot and cold water may be dashed over the chest alternately, or hot cloths applied over the

præcordia. Faradism of the phrenic, often advocated, is of doubtful value, and batteries are not usually at hand, or, if at hand, in working order. The lips should be rubbed with a towel or moistened with brandy, a hot-water bottle applied to the feet, and 10 ounces of plain hot water or saline injected into the rectum by means of an ordinary Higginson syringe. This last is a most valuable measure. Injections of pituitrin are useful, suitable ampoules being retailed by Messrs. Burroughs and Wellcome, and 10 minims of the 1 : 100 liq. strychninæ may be injected as an alternative. Dr. Gordon Sharpe, of Leeds, advocates heroic doses of this drug.

Asphyxia.

Mechanical obstruction is almost invariably the cause of asphyxia occurring during the course of anæsthesia in dental work induced by nitrous oxide or ether. In ethyl chloride we sometimes get a fairly early asphyxia or respiratory failure due to spasm of the respiratory muscles, etc., which is again probably due to overdose for the individual.

Asphyxial conditions are more common, however, in the recovery stage of anæsthesia, and signalized by increase of cyanosis and lividity. Careful sponging, the removal of all loose teeth

and fragments of teeth, and the restriction of bleeding, are obviously important factors in avoiding asphyxia.

One of the authors recalls a case which caused him very great anxiety at the time, due to the patient vomiting when half under and filling the face-piece and air-way with the undigested remnants of his breakfast.

Whatever may be the cause, however, there is a clear indication on all occasions. The patient wants air, and the air-way must be cleared at once and his breathing carried on for him.

Signs of Commencing Asphyxia.—Increase or return of the lividity, which rapidly extends all over the surface of the patient's body; gasping and struggling for breath, terminating in actual convulsions and in cessation of respiration. The violent respiratory efforts, as well as the non-oxygenation of the blood, themselves act as cardiac depressants, and the heart's action is seriously impeded and finally stops.

It must be borne in mind that the actual movements of the chest may continue in spite of the complete occlusion of the larynx, and we must therefore rely only on the *audible respiratory sounds* for evidence that air is entering the lungs.

Treatment of Asphyxia.—Prevention being better than cure, all possible precautions should

be taken at all times as regards dental props and loose teeth in the mouth when an extraction is going on under general anæsthesia.

The average anæsthetist regards the passing of a tooth down the patient's air-passages as the gravest risk during anæsthesia for dental purposes. A tooth down the air-passages may cause spasm of the glottis, calling for an immediate tracheotomy, and lead later to a painfully protracted septic pneumonia involving, as we have known it, years of illness and subsequent litigation. We have often trembled at the haphazard way some extractors, especially students, have left portions of teeth or whole teeth lying around the patient's mouth while they completed an extraction. The Trewby Dennis oral shield and Carter's net spoon are useful in preventing teeth jumping back into the throat, as the lower bicuspids are specially apt to do.

As regards the immediate treatment of asphyxial conditions, the first steps are, as indicated above, to clear the air-way and carry on the breathing. If the blood, mucus, or foreign body be within reach it should be removed by appropriate measures—finger, throat forceps, or sponge. Assistance may be given by the old-fashioned smack on the back.

The offending body may be rapidly expelled by

the coughing, and complete relief be afforded, or the dyspnœa may pass off suddenly owing to the position of the foreign body becoming altered. On the other hand, if the dyspnœa increases, immediate relief will be called for by tracheotomy or laryngotomy; in young people inversion should first be tried, but with adults this is often practically impossible and waste of time.

The patient should be laid on the floor, shoulders raised and head extended, and the larynx should be opened between the thyroid and cricoid cartilages; a tube, if available, should be inserted—or failing this a clean toothpick—or the wound edges kept carefully retracted by means of a bent hairpin or hook. Artificial respiration should then be started.

If the respiratory difficulty is due to thick tenacious mucus or partially clotted blood and mucus sticking about the pharynx, the patient's head should be bent forward, and he should be encouraged to cough and smacked on the back. If this fails, a coarse, dry sponge on a handle should be thrust well back into the pharynx and withdrawn rapidly with a sweeping movement. If this be done, the operator should be quite clear that the obstruction is not due to a solid body—loose tooth or the like—or more harm than good may result. Apart from foreign bodies, mucus,

and blood, it must be borne in mind that asphyxial symptoms may be produced by spasm of the aryteno-epiglottidean folds (especially in chloroform anæsthesia in young people, infants, and the like), and here the remedy, as originally pointed out by Lord Lister many years ago, is simple rhythmic traction of the tongue.

CHAPTER X

THE L.D.S. DIPLOMA AND THE ADMINISTRATION OF ANÆSTHETICS

How far are dentists, holding the L.D.S. diploma only, legally entitled to administer anæsthetics ?

It is often held that this diploma confers the right to administer nitrous oxide, but no other anæsthetic. For this idea, however, there is no actual legal basis, but it has grown out of the fact that nitrous oxide is commonly regarded as one of the dentist's ' tools,' and practically a part and parcel of his calling.

The law is absolutely ambiguous on the point, and in the few cases in which a fatality has occurred and which have actually come into court to be decided upon, the decision of the presiding judge has largely hinged on the amount of skill presumably possessed by the person responsible for the anæsthetic, and little account has been taken of the fact whether the person administering the anæsthetic actually had any qualification or not in the way of a diploma. The fact is, of

course, that a judge is scarcely capable of dealing with such a technical matter, and he is not in a position to say whether any case was conducted with a proper amount of skill or not.

In the Metropolis it has for many years past been the custom for a dentist in good class practice to ask the help of a professional anæsthetist, whenever a patient comes to him requiring gas or any other anæsthetic, or at any rate to get a medical practitioner of rather more than ordinary experience in anæsthetic work to help him. In the provinces of England, also, it has been usual to ask either the patient's own doctor or a neighbouring medical practitioner to be present, and, if possible, to assist in giving the anæsthetic which was required, even if it were only nitrous oxide. We believe this to be largely due to the inevitable coroner's inquest if a fatality occurs—an ordeal which has not to be faced in Scotland. In this country practice differs considerably. Dental surgeons almost invariably give gas, and if the extraction be not very complicated they even administer gas and ether, and ethyl chloride and ether, themselves. Indeed, since the introduction of ethyl chloride during the past two years, this anæsthetic has been administered broadcast by the dental surgeons holding the L.D.S. diploma, and even by dentists

holding no qualification whatever. Only in exceptional and prolonged cases has it been the custom to ask for outside assistance on the part of medical men or a special anæsthetist. Cases have occurred in which patients suffering from grave cardiac and respiratory disability have gone to their dentists, and on the removal of one or more teeth being decided on, gas, gas and ether, or ethyl chloride and ether, has been given on the spot, in the most offhand manner. That fatalities have occurred is not to be wondered at, and this is surely a state of matters which should not be permitted to continue.

The dental profession is scarcely to be blamed altogether for the position which has arisen. Until ten or twelve years ago, at any rate, to ask a medical practitioner in Scotland to give an anæsthetic for a dental or any other operation meant, in ninety-five cases out of a hundred, *chloroform*. So many fatalities have occurred in dental practice under this anæsthetic that there is a marked tendency to fight shy of it on the part of dental surgeons at the present time, and they, having so far made themselves familiar with modern anæsthetic methods—and as regards their knowledge in this respect being rather in advance of the bulk of the members of the sister profession of medicine—are at the present moment somewhat inclined

to take the law in their own hands, and be responsible both for the anæsthetic and the operation. This is very unfortunate in many ways. For one thing, no one who is going to carry out an operation, be it the extraction of a number of teeth or otherwise, should be responsible for the anæsthetic also; the risk to the patient under such conditions is greatly increased.

Patients have been known to die during nitrous oxide anæsthesia, just while a tooth was being extracted, without the operator being aware of it. A case such as this occurred some years back, where, although the patient must have obviously been becoming rapidly asphyxiated, the person extracting the teeth (an unqualified dentist) was so much taken up with his work at the moment that he failed to recognize the patient's dangerous condition until it was too late. Had a responsible person been superintending the anæsthesia, and prompt measures been taken, there is no doubt that an accident would have easily been avoided. The medical profession, and more especially those responsible for medical education, are undoubtedly to blame for the state of matters which exists. Until recently no attempt has been made to see that candidates for the qualifying medical diploma have familiarized themselves with the better-known anæsthetic agents, and, indeed, the ignor-

ance of the average medical practitioner of such a commonly used anæsthetic as nitrous oxide has been notorious.

A step in the right direction has now been taken, however, in seeing that practical instruction in anæsthetic work is carried out at the various teaching hospitals, and we may hope that in a year or two the lamentable state of ignorance which has existed will be a thing entirely of the past. When the dental profession realizes that they, individually, have a medical practitioner at hand ready to intelligently help them with the management of the anæsthetic at any time, they will doubtless, in their own interest and in that of the patient, avail themselves of his assistance. Few things can be more damaging to a practice than for a patient to die under an anæsthetic in a dental chair, and it is not too much to say that, looking at the matter from the lowest and merely financial standpoint, a dental practitioner will lose more on the day that such an accident happens, from actual damage to his practice, than he would pay away in fees to a medical man in ten years, even were he to do it all out of his own pocket. The question is a very difficult one to deal with, as is also the whole question of the relations between the dental surgeon and the family doctor, as regards the administration of anæsthetics. Do

we not almost weekly see in the medical journals questions asked on the ethics of this matter? A patient A. has a medical attendant Dr. B., and on A. going to consult a dentist C. he tells A. that he will get D., another medical man, to give A. an anæsthetic. Dr. B. hears of the matter, and there are difficulties and heartburnings. Now, the proper action seems to be this:

When a patient comes for the first time to a dental surgeon and an extraction is required, it seems to be the right thing for the dentist to communicate with the patient's own doctor, and ascertain if there be any contra-indication to a general anæsthetic, or any constitutional disability requiring caution. Having done this, it seems to the writer that the dental surgeon is entitled to ask whomsoever he pleases to give the anæsthetic. If he knows the doctor not to be very skilled in anæsthetic work, he naturally will choose to get someone in whom he has confidence, and with whom he is accustomed to work, in his own and the patient's interest. In some cases the patient will himself ask that his ordinary medical attendant may either be present or actually administer the anæsthetic, and in such a case, unless he have the strongest possible reasons, the dentist will surely do well to give his consent. But the essential point is that, if an anæsthesia of anything but

a trifling kind be undertaken, an intimation be made to the medical attendant, and this should especially be the case if the patient is at the time actually under his treatment. In doing this, in the vast majority of cases there should be no difficulty, either by note or telephone message.

If it be impracticable for some reason, the optional course is to hand the administration of the anæsthetic and the responsibility for the whole matter over to a fully-qualified and expert medical man, who will examine the patient and ascertain any particulars as to the physical condition, and take such precautions as are necessary and indicated by what the patient tells him.

The importance of this matter cannot be too much emphasized. By communicating with the patient's own doctor, the dentist is treating him with courtesy, and in a way which he will surely not be slow to appreciate; he is looking after the patient's best interests, and keeping himself on the right side.

There seems to be no question that the casual administration of *any* anæsthetic to patients who happen to drop into a dentist's surgery without any physical examination, and without any inquiries as to their general health or physical ailments, cannot be too strongly discouraged.

It is quite impossible that all anæsthetics can

be administered by experts or, with the present state of the Medical Acts, even by men with a medical diploma, but there seems no adequate reason why every precaution cannot be taken, and with the person who neglects to take them and gets into trouble we have little sympathy when he meets with the well-deserved censure of the coroner or procurator-fiscal.

APPENDIX

A Summary of Deaths under Nitrous Oxide Gas, collected from Many Sources.

Case 1.—January 22, 1873, Exeter; female, æt. 38; stout; enlarged tonsils and uvula; dental operation, semi-recumbent; double administration; asphyxia.

Case 2.—March 27, 1877, Manchester; male, elderly; obese; dental operation; double administration; asphyxia.

Case 3.—September 15, 1883, London; male, æt. 57; tongue enlarged by morbid growths and fixed; dental operation; convulsive tremor and rigidity; asphyxial syncope.

Case 4.—1885, Paris; male, æt. 50; dental operation; 'syncope.'

Case 5.—October 1, 1887, Edinburgh; female, æt. 71; stout; corsets tight; food in stomach; dental operation; probably 'asphyxia.'

Case 6.—1890, Montreal; male, æt. 24; dental operation; 'syncope.'

Case 7.—May 1, 1892, Buffalo, U.S.A.; female, married; dental operation; cause uncertain.

Case 8.—1893, Batley; male, æt. 39; small, deformed lower jaw; dental operation; asphyxia.

Case 9.—1893; female; dental operation; asphyxia.

Case 10.—February 21, 1894; male, æt. 26; enlarged tonsils, receding lower jaw, short neck; dental operation; asphyxia.

Case 11.—January, 1895, Preston; female, æt. 23; tight corsets; full stomach; dental operation; asphyxia.

Case 12.—October 7, 1895, New York; female, æt. 22; dental operation.

Case 13.—1895, Chestnut Hill; male; dental operation; asphyxia.

Case 14.—March, 1899, Birmingham; male, æt. 12; large abscess in base of tongue; fixed lower jaw; horizontal posture; extension of head; opening of abscess; asphyxia.

Case 15.—Reported in 1899, London; male, æt. 71; very delicate; old pericarditis and pleurisy; dorsal posture; operation for adenoids (N_2O and air); syncope; no respiratory obstruction.

Case 16.—June 15, 1899, London; female, æt. 27; food in stomach; operation on elbow; double administration; vomiting; dusky pallor; 'syncope.'

Case 17.—November, 1900; male, æt. 36; suppuration of neck; left tonsil swollen, incision of neck (N_2O first, then with air); respiration stopped; asphyxia; post-mortem, 'laryngeal œdema.'

Case 18.—December 20, 1902; female, æt. 20; abscess of the tonsil.

Case 19.—In 1903, Chelsea; female, æt. 23 months; operation for adenoids; 'spasm of the glottis.'

Case 20.—May, 1905, at Carlisle; female, æt. 17; dental extraction; asphyxia; unqualified dentist.

In addition to these perfectly authentic cases, there are thirteen others, of which three are imperfectly recorded, and the remainder occurred in such a way as to render it extremely dubious whether the anæsthetic was to blame in any degree.

Deaths from Somnoform and Ethyl Chloride which have been recorded as occurring in the United Kingdom.

Fatalities under Ethyl Chloride.

About ten years ago something of a 'scare' was worked up over ethyl chloride, and some well-known anæsthetists practically refused to administer this drug. While one cannot altogether understand their attitude, there is no doubt that, in unskilled hands, it is an anæs-

thetic which should be used with a great deal of caution, both as regards dosage and length of administration.

The idea had got about among a large number of both the medical and dental professions that ethyl chloride was a sort of glorified nitrous oxide, which one can carry about in one's waistcoat pocket and administer to all and sundry, without any special precaution or skill on the part of the administrator.

Nothing farther from the facts of the case could be imagined, and the somewhat formidable list of fatalities below (in view of the youth of ethyl chloride as a general anæsthetic), which the authors have been at some pains to get together, will, they trust, go far to check the indiscriminate use of the drug. Its highly toxic character and the danger due to the great rapidity of its action should be fully recognized, as well as its admirable properties as an adjuvant to chloroform and ether. There can be no doubt about its value in this respect, but discrimination is required in regard to its use, as in many things. Beyond one or two cases of respiratory arrest—when the authors first began using ethyl chloride—they have never seen any trouble from it in an experience of some two thousand cases, but they early recognized the necessity for small dosage, and great care and watchfulness in its administration.

1. Lotheisen's case; male, æt. 41; alcoholic and cardiac disease; at Innsbruck (*Münch. Med. Wochenschr.*, November 18, 1900).

2. Bossart's case; child, æt. 12 months; suffering from diphtheria; at Aaran (*Correspond.-Blatt für schweizer Aerzte*, October, 1902).

3. Olcott Allen's case; male, æt. 28; operation for hernia; vomited a lot of fluid, and died of asphyxia (*American Journal of Medical Science*, December, 1903).

4. Female; suffering from advanced dropsy; at Dublin (*Lancet*, October 7, 1905).

5. Male; suffering from swelling in the neck (*Lancet*, October 7, 1905).

6. Male; abscess in jaw (*Lancet*, October 7, 1905).

7. Male; dental case (*Lancet*, October 7, 1905).

8. Male; a seaman at Haslar Hospital; dental operation (*Portsmouth Evening News*, April 24, 1905).

9. Female, æt. 50; at Stourbridge (*British Medical Journal*, July 8, 1905).

10. Female, æt. 40; at Enfield; dental case; 'somnoform' was used (*British Journal of Dental Science*, April, 1904).

11. Female, æt. 42; dental case; locality unrecorded (*British Journal of Dental Science*, April 1, 1904).

12. A boy, æt. 10; operated on for adenoids and tonsils at a Plymouth hospital (*General Practitioner*, August 19, 1905).

13. A death occurred at Llandudno in the summer of 1903.

14. A death occurred at Swansea in 1904 also during a dental extraction.

15. A death occurred in Edinburgh in July, 1905, during a dental operation, patient being a delicate woman of 50 years of age.

16. A further death occurred in an Edinburgh hospital in the same month and year.

17. Two fatalities occurred in Carlisle in 1905.

18. A death occurred in London, February, 1906, in a dentist's chair.

19. A death occurred at a Bradford hospital in 1906 during a throat operation.

20. In January, 1906, a death occurred at Oxford.

21. In 1905 a death occurred at Leeds; and

23 and 24. Two deaths in the same year at the Mustapha Civil Hospital, Algiers.

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